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ORIGINAL ARTICLES.

I.—Notes on the Invertebrate Fauna of the Uitenhage Series in Cape Colony.

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(Communicated by permission of the Director of the Geological Survey of Cape Colony.)

THE rich invertebrate fauna of the Uitenhage Series has long attracted attention, owing to the conspicuous nature of some of its components and the divergence of opinion which has arisen in the various attempts to bring it into correlation with Secondary faunas in the European area. A recent examination of the fossils collected from the Uitenhage Beds by the Geological Survey of Cape Colony has afforded an opportunity of reconsidering, in the light of extended knowledge, the conclusions of those who have previously studied this question of correlation. A comparative study of the fauna, with an account of some new species, based principally upon the materials collected by the members of the Survey, will shortly be contributed to the fourth volume of the "Annals of the South African Museum"; but in the meantime, the following brief notes, in which are embodied some of the principal results, may be of interest to a wider circle of readers.

The most comprehensive published accounts of the Uitenhage Beds, including the results of the recent surveys, are those written by Mr. A. W. Rogers and Professor E. H. L. Schwarz.[1] As regards the affinities of the marine fossils, the view that these indicate a Lower Cretaceous age has been most convincingly upheld in the palæontological studies of Krauss and Neumayr,[2] whose opinion is the one which is now most widely accepted. Sharpe and Tate,[3] on the other hand,

[1] Rogers & Schwarz, "Report on the Survey of parts of the Uitenhage and Port Elizabeth Divisions": Ann. Rep. Geol. Comm., 1900, p. 3; Cape Town, 1901. Rogers: "An Introduction to the Geology of Cape Colony," pp. 281–318, 1905. Rogers, "Geological Survey of parts of the Divisions of Uitenhage and Alexandria": Ann. Rep. Geol. Comm., 1905, pp. 15–33, 45; Cape Town, 1906.

[2] F. Krauss, "Ueber einige Petrefacten aus der untern Kreide des Kaplandes": Nova Acta Acad. Cæs. Leop.-Carol. Nat. Cur., vol. xxii, pt. 2, p. 439; Bonn, 1850. M. Neumayr, in E. Holub & M. Neumayr, "Ueber einige Fossilien aus der Uitenhage-Formation in Süd-Afrika": Denkschr. d. k. Akad. Wiss., Math.-Nat. Classe, Band xliv, p. 267; Vienna, 1882.

[3] D. Sharpe, "Description of Fossils from the Secondary Rocks of Sunday River and Zwartkop River": Trans. Geol. Soc. Lond., ser. II, vol. vii (1856), p. 193. R. Tate, "On some Secondary Fossils from South Africa": Quart. Journ. Geol. Soc., vol. xxiii (1867), p. 139.

believed the fauna to be of Jurassic age, and their view has until recently continued to find adherents. A few authors have suggested that the series may be in part Upper Jurassic and in part Lower Cretaceous.

The great majority of the invertebrate fossils collected from the Uitenhage Beds consist of Mollusca, and have been obtained from localities in the valleys of the Sunday's, Zwartkop's, and Coega Rivers. A more detailed examination of the fauna than that undertaken by previous writers fully corroborates Neumayr's conclusion that a large percentage of the Mollusca show affinity to Cretaceous rather than to Jurassic forms. There is, moreover, abundant evidence in support of the opinion of those who have ascribed to the Uitenhage Series a Lower Cretaceous age, although, as might be expected, there are a few bivalve forms which bear a somewhat close resemblance to familiar Jurassic types. It will suffice, however, to mention the presence of *Holcostephanus* (sensu stricto), the restricted group to which V. Uhlig and F. Suess have applied Pavlow's name *Astieria*, typified by *H. astierianus* (d'Orb.); *Hamites*; *Crioceras*; *Bochianites*; *Hoplites* (sensu lato), here represented only by *Acanthodiscus*, Uhlig, and perhaps also *Solgeria*, Uhlig; *Trigonia* of the divisions Scabræ and Pseudo-quadratæ; *Ptychomya*; *Thetis*, and *Solecurtus*. All these, so far as we know, are confined elsewhere to the Cretaceous rocks, and taken together, they give most decisive evidence of a Lower Cretaceous age. In Europe, *Holcostephanus* (sensu stricto) is almost wholly, if not entirely, confined to strata of Upper Valanginian and Lower Hauterivian age, and this genus is so richly represented in the Uitenhage Beds as to suggest strongly the soundness of a correlation with this part of the Neocomian stage. It has been frequently stated that *Holcostephanus atherstoni* (Sharpe), a Uitenhage species, actually occurs in the Lower Hauterivian of Europe; and although a careful examination of the evidence fails to bear this out, there can be no doubt that several *Holcostephani* in Cape Colony are intimately related to certain European forms. The remains of plants found in the Uitenhage Beds do not give such definite indications of geological age as the Mollusca, but it will be remembered that Professor A. C. Seward has expressed the belief that the balance of evidence furnished by the plants is in favour of a Wealden age.

It becomes a matter for some astonishment that Tate should have expressed so positively the opinion that the Uitenhage fauna is of Jurassic character, and should have arrived at the curious conclusion that these supposed 'Oolites' of South Africa represent the whole of the Jurassic rocks of Europe with the exception of the Upper Oolites, and illustrate an intermingling of palæontological types which are analogous to, or identical with, those distributed in successive zones in Europe. A study of the actual specimens upon which Tate based these conclusions shows clearly that he failed to see the true significance of the Cephalopoda, and that while making use of some bivalve types little adapted to serve the purposes of a critical correlation, he was further misled by several quite erroneous identifications.

Restricting our attention to the marine development of the Uitenhage Beds, it may be stated confidently that there is no palæontological

evidence to show that even a part of the series is of earlier age than Neocomian. Those very forms which, if taken alone, might with some justification have been thought to indicate a Jurassic age, occur relatively high up in the series in association with shells of undoubted Neocomian type. On the other hand, some of the more characteristic marine forms have been shown by Mr. Rogers to occur near the base of the great Sunday's River sections as well as at higher horizons, and to have a much more extensive vertical range in the series than was formerly suspected. The closely similar nature of the marine fauna found at various horizons, together with other evidence, points to conditions of relatively rapid deposition. This unity of character, as shown by a study of the whole fauna, and also the fact that the Surveyors failed to find evidence for zonal differentiation which might be utilised in establishing any scheme of palæontological subdivisions in the series, seems to indicate without doubt that a very restricted time-period is represented by the whole of the marine beds. In considering the relations of the fresh-water beds to the strata of marine origin, Messrs. Rogers and Schwarz have sufficiently emphasised the part played by rapid contemporaneous variation of facies, and have shown how this factor precludes even a broad, generally-applicable classification, based upon a consistent succession of fresh-water and marine beds.

Representatives of the Lamellibranchiata largely preponderate among the Uitenhage Mollusca, and many of them provide data which usefully supplement the more desirable evidence afforded by the cephalopod-types, in the question of a correlation with European standards. When, however, we seek to trace relationships between the Uitenhage molluscs and those of Lower Cretaceous deposits situated in extra-European regions, it becomes necessary to rely almost entirely upon the evidence of the lamellibranchs, leaving out of account the fact, recognised by Pavlow and Uhlig, that some of the *Holcostephani* of the Uitenhage Series show near affinity to *H. scheùki* (Oppel), from the Spiti Shales. Certain lamellibranchs, some of which are well-characterised forms, point to the relationship which existed between this development of the Neocomian in Cape Colony and the Oomia *Trigonia*-beds in Cutch, the strata yielding *T. centricosa* (Krauss) in the Godavari district and in Hazara, the Neocomian deposits in German East Africa, and the Lower Cretaceous strata of presumably like age in Chili, Bolivia, and the Argentine Republic. In making these comparisons, important significance must be attached to the evidence of some of the *Trigoniæ*, notably of the divisions Pseudo-quadratæ and Scabræ.

F. Stoliczka, W. Waagen, O. Feistmantel, W. T. Blanford, and R. D. Oldham, all drew attention to the apparently close relationships existing between some of the bivalves in the Oomia Beds of Cutch and certain species in the Uitenhage Series, and the recent study of these faunas has shown that the evidence for such relationship is, in truth, of a very striking character. It is well known that a species of *Trigonia* which occurs very abundantly in the Oomia Beds was referred by the Indian geologists to *T. centricosa*, first described by F. Krauss from the Zwartkop's River, Cape Colony. Although many of the

Indian specimens show a rather less degree of inflation than individuals representing the average characters of the species in South Africa, I do not consider that the points of distinction are such as to warrant specific separation, or even to permit the certain recognition of two well-defined local races. Should, however, the correctness of this opinion be called in question, the very close resemblance between the shells ascribed to *T. ventricosa*, from these widely separated habitats, must retain the strongest significance, when viewed in connection with the evidence for relationship between some of the associated forms in the one area and certain of those in the other. Several bivalves of the Uitenhage Beds, including such specialised forms as *Cucullæa krausst*, Tate, and *Sebachia brouni* (Krauss), have very closely comparable, and perhaps identical, representatives in the Oomia group, and a new *Trigonia* from the Sunday's River Beds, belonging to the specialised and short-lived group Pseudo-quadratæ, bears a close resemblance to *T. mamillata*, Kitchin, a member of the same division of the *Trigoniæ*, from Cutch. The association of these Indian forms with a large *Gervillia* which closely resembles *G. dentata*, Krauss, has already been made known. The striking similarity between the *Trigoniæ* of the group of *T. v-scripta*, Kitchin, in the Oomia Beds, and the group of *T. rau*, Sharpe, in the Uitenhage Series, has been discussed elsewhere,[1] and while the adult stages in the members of the two groups probably illustrate homœomorphy, the presence of these analogous forms only serves to emphasise the remarkable aspect of similarity shown when we place side by side the identical and proximate types in the faunas of these widely separated areas. A review of the evidence so far available must certainly lead to the inference that these faunas in South Africa and India are approximately contemporaneous, and that the lines of intercourse between the two areas at that time were probably much more direct than was believed by Neumayr, W. T. Blanford, and others, to be the case. The evidence for the age of the Uitenhage fauna is so decisive that it becomes necessary, by means of this indirect correlation, to refer the *Trigonia*-bearing beds of the Oomia group to the Neocomian.

In the case of the Neocomian fauna in German East Africa which G. Müller believes to be related to that of the Uitenhage Series,[2] the evidence is of a somewhat less satisfactory character, but I am of opinion that the indications are sufficiently clear to show the correctness of Müller's view. Here, again, peculiarly characterised *Trigoniæ* are a special feature in the fauna, and some of these recall Indian and South African forms. For example, *T. kuhni*, G. Müller, possesses characters which appear to indicate relationship to *Trigoniæ* of the group of *T. rau*, Sharpe, or the group of *T. v-scripta*, Kitchin, while *T. beyschlagi*, G. Müller, very closely resembles *T. crassa*, Kitchin, a degenerate costate form which occurs abundantly in Cutch. Another *Trigonia* has been referred by Müller to *T. ventricosa* (Krauss), and a large *Gervillia* is very closely comparable with *G. dentata*, Krauss, if it is not actually identical with it.

[1] F. L. Kitchin, "The Jurassic Fauna of Cutch," vol. iii, pt. 2, No. 1, *Trigonia*, p. 66: Palæontologia Indica, ser. ix (1903).

[2] G. Müller, "Versteinerungen des Jura und der Kreide": Deutsch-Ost-Afrika, Band vii, pp. 514–571: Berlin, 1900. F. L. Kitchin: op. cit., p. 121.

A search for traces of the characterising features of the Uitenhage fauna among the Lower Cretaceous fossils described from South America also reveals evidences of a suggestive kind, as recognised by several authors. From the Belgrano Beds in Patagonia, T. W. Stanton[1] has described two *Trigoniæ* which at once recall South African forms. *T. subventricosa*, Stanton, appears to be nearly allied to *T. ventricosa* (Krauss), and *T. heterocalpta*, Stanton, not only exhibits a peculiar type of adult ornamentation comparable with that exemplified by *T. cau*, Sharpe, and another related South African form, but its adolescent characters show that there is in all probability true relationship with this group of *T. cau*. Here, again, in the Belgrano Beds is found an associated *Gervillia* of large dimensions which does not seem to be widely removed from *G. dentata*, Krauss, of Cape Colony. From Chili, R. A. Philippi has described *Trigoniæ* which share the characters of peculiar sculpture and siphonal prolongation exhibited by the group of *T. cau*, Sharpe, and are probably related forms. The *Trigoniæ* of the group Pseudo-quadratæ described by G. Steinmann, R. A. Philippi, and C. Burckhardt from Lower Cretaceous beds in Bolivia, Chili, and the Argentine Republic, form an important connecting link with the Uitenhage fauna. *T. transitoria*, Steinmann, a member of this well-marked group, occurs with significant associates in the *Trigonia*-beds of Neocomian age exposed on the left bank of the Rio Agrio opposite Las Lajas, Argentine Republic.[2] These beds yield another member of this group of *Trigoniæ*, and also a species which very closely resembles *T. conocardiiformis* (Krauss), one of the most characteristic forms in the Uitenhage fauna. *T. eximia*, R. A. Philippi, from the Tinguirica valley in Chili, appears to be very closely related to these. The Chilian shells ascribed by Bayle and Coquand to *Ostrea couloni* bear a considerable resemblance to *Exogyra imbricata*, Krauss, of South Africa, with which Coquand himself later ventured to identify them. Accompanying this oyster in Chili is *T. delafossei*, Bayle & Coquand, the resemblance of which to *T. ventricosa* (Krauss) has been remarked upon by J. Lycett, W. Paulcke, and myself.

From this brief sketch it may be seen that certain groups of bivalves which form characterising elements as yet unknown to occur in Europe, have a remarkably wide distribution in a Neocomian development of southern type. Thus, *Trigoniæ* of the group Pseudo-quadratæ occur in India, Cape Colony, and South America: *Trigoniæ* of degenerate costate type, unknown elsewhere, are found in Cutch and in German East Africa; *Trigoniæ* of the groups of *T. c-scripta* or *T. cau* occur in Cutch, German East Africa, Cape Colony, and South America: *Trigoniæ* of the type of *T. ventricosa* are also met with in India, East Africa, Cape Colony, and South America; the remarkable form *T. conocardiiformis* has a close counterpart in South America: the genus *Scabrotrigonia* is known from Cutch and Cape Colony, while a species of *Cucullæa* which exhibits some striking distinguishing features has

[1] T. W. Stanton: Rep. Princeton Univ. Exped. to Patagonia, 1896–1899, vol. iv, pt. 1, Marine Cretaceous Invertebrates, pp. 18, 20, 1901.

[2] C. Burckhardt, "Beiträge zur Kenntniss der Jura- und Kreideformation der Cordillere": Palæontographica, Band l. (1903), pp. 72–75.

a similar distribution, and, like *Seebachia*, is without any near representative in the European area. The distribution of *Gervillia* of the type of *G. dentata* and large *Exogyra* resembling *E. imbricata* may perhaps also be allowed to have some significance when considered in relation to the occurrence of the forms with which they are associated.

These, in brief, are some of the more significant facts which must be borne in mind when we consider the broad questions of distribution which arise from a comparative study of the Uitenhage Mollusca. Having regard to the manner in which a number of the ammonoids from the Sunday's River Beds permit of close comparison with related European types, it is surprising that these South African forms or even closely allied species are as yet unknown to occur in Cutch, and their apparent absence from the Neocomian deposits of German East Africa and of South America is also noteworthy. Nevertheless, a study of the Uitenhage fauna, undertaken in the light of fuller knowledge, dispels the idea, put forward and emphasised by M. Neumayr, that this fauna proclaims its isolated position by the sharp contrast it shows to the comparable faunas of other regions, and that it may hence be considered to support the theory of an Indo-African land-barrier in early Cretaceous times.[1] Neumayr laid great stress upon the contrast between the fauna of the Neocomian belemnite-beds in the north-west of Madagascar and that of the Uitenhage Series. Even allowing that these faunas are strictly contemporaneous, which has not yet been demonstrated, it is probable that the difference of facies, as recognised by P. Lemoine, would alone suffice to account for the contrast. These belemnite-beds in Madagascar probably represent comparatively deep-water conditions, while the Uitenhage fauna exhibits a shallow-water, littoral character. Since the time when Neumayr wrote, great advances in our knowledge of the occurrence of Cretaceous deposits in Madagascar and on the neighbouring African coast have been made by French geologists, and many facts have now been brought to light which cast doubt upon the existence of an effective barrier to migration between the equatorial and southern waters to the east of the African continent in Cretaceous times. It may reasonably be asserted that the evidence derived from a study of the Neocomian fossils of Cape Colony gives no support to Neumayr's view.

It is well known that Neumayr attached great importance to the occurrence of *Belemnites africanus*, Tate, in the Uitenhage Series in support of his theory of the distribution of cephalopods according to climatic zones.[2] He found this form to belong to a group which, though occurring in the colder waters of the northern hemisphere, is without representative in the warmer equatorial regions. The known distribution of *Holcostephanus* (sensu stricto) might be thought to contribute in like manner and with no less force of suggestion to the

[1] M. Neumayr, "Die geographische Verbreitung der Juraformation": Denksch. d. k. Akad. Wiss. Wien, Math.-Nat. Classe, Band l. (1885), p. 57. "Erdgeschichte," Band ii. 2nd ed., pp. 259, 261, 295, 296, 529; Leipsic and Vienna, 1895.

[2] M. Neumayr, "Ueber neuere Versteinerungs-funde aus Madagascar": Neues Jahrb. für Min., 1890, Band i, p. 1.

evidence in support of the broad principle laid down by Neumayr, but we must hesitate before attaching any such significance to the facts. Our knowledge is as yet very incomplete, and, moreover, a body of evidence relating to the distribution of fossil Cephalopoda has now been accumulated which casts the strongest possible doubts upon the soundness of Neumayr's theory.[1] Facts set forth in the writings of S. Nikitin, F. Kossmat, C. Burckhardt, G. Boehm, and other authors show clearly the necessity of exercising the greatest caution in estimating the significance of the Uitenhage cephalopods in any general question of distribution. The apparent absence of identical or closely related forms from the Neocomian rocks of German East Africa and of Cutch is very probably owing to our imperfect knowledge of the fossil faunas in these districts; but if this be not the case, the real absence of these cephalopods may possibly have been determined by conditions of a local nature, in manner not unknown among the cephalopod-faunas of various geological horizons within restricted areas in Europe. The same remarks apply to the Neocomian faunas of South America, which have not yet been shown to include any of the South African *Holcostephani* or related forms; but it need scarcely be mentioned that the absence of these Cephalopoda in South America, even though real and not merely apparent, could not be utilized as negative evidence in support of Neumayr's theory. It may be remarked, finally, that the indications for relationship between the bivalve faunas of the Uitenhage Series and the Lower Cretaceous deposits in South America rather tend to strengthen the view, supported by other evidence, that an ancient land surface at that time connected the African and South American continents.

II.—The Lower Ordovician Rocks of Scandinavia, with a Comparison of British and Scandinavian Tremadoc and Arenig Rocks.

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(WITH A MAP, PLATE X.)

(*Concluded from the June Number*, p. 267.)

CONSIDERING now the details of the various districts, we notice that in South Öland the basal beds are shaly and conglomeratic; the higher part is calcareous, and by increase in the proportion of matrix passes into a creamy-white limestone which is wonderfully fossiliferous (O 1 and C). The highest beds are again glauconitic, soft, and shaly. Northward the proportion of calcareous material diminishes, and a band of shale with *Shumardia*, whose lithology and fossil content agree with that of the Ottenby *Ceratopyge* shales below the unconformity, is interstratified with the limestone. This bed is quite inconstant, but in Central Öland another shale band containing *Eulomia* occurs low down in the limestone. Beyond Borgholm (O 5 and O 6) all limestone disappears, and only glauconitic shale separates the

[1] M. Neumayr, "Ueber klimatische Zonen während der Jura- und Kreidezeit": Denkschr. d. k. Akad. Wiss. Wien, Math.-Nat. Classe, Band xlvii (1883), p. 277.

alternating of *Dictyonema* shale and *Obolus* conglomerate from the *Orthoceras* limestone above. In Central Oland the glauconite shales and Ceratopygekalk attain their maximum thickness of nearly seven feet, but in the north are again reduced to little more than one foot.

In Vestergötland the detailed succession is particularly variable. Fossils are abundant, especially in the dark pyritous limestone of Hunneberg and Halleberg (W 6), where, however, only the very highest beds of Brögger's $3a\gamma$ (K 1) seem to be represented. At Kinnekulle (W 2) the succession is much the same as in South Oland, and the creamy limestone is equally fossiliferous. The passage upon both these places takes place through alternations of shales and limestones, and well-preserved Arenig graptolites can be found within a foot of the Ceratopygekalk. In the south of Falbygden (W 4 and W 5) the beds are less than three feet thick, and the limestone and glauconite alternate with thin bands of pale-green shale like the graptolite shales above. At Klefva on Mösseberg the whole division is reduced to a single inch of glauconitic sand or shale, and the *Phyllograptus angustifolius* of the higher series can be obtained within three inches of fine specimens of an early type of *Dictyonema*. Near Sköfde (W 3), in the northern part of this district, a most unusual bank of amorphous blotchy limestone, 20 inches thick and without Korrosionsgruppar, separates the two feet of glauconitic limestone from the shales above. About Berg (E 1) in Östergötland the Glauconiteskiffer is unconsolidated and very like the 'slubber' from the washing of Cambridge Greensand; the green limestone above is like the upper limestone of Kinnekulle, and must represent a very high Ceratopygekalk horizon.

In Nerike the *Ceratopyge* beds have been said to be missing. Shales with *Shumardia* are described by Wiman[1] as occurring some distance above the basal glauconitic marl. The beds here show well-marked Korrosionsgruppar, but are referred by Wiman to the Planilimbatekalk, so the question must be regarded as still *sub judice*.

Glauconitskiffer have already been mentioned as occurring among the drift of Gefle, where they contain the rich fauna described by Wiman (B 1).

In Dalarne, as seen in the Rettvig–Vicarby railway cutting, the *Obolus Apollinis* conglomerate passes up into rather finer but similarly constituted beds containing much glauconite. These are some three or four feet thick, and are overlain by a six-inch bed of loose glauconite sand and another six inches of green limestone with Korrosionsgruppar and *Symphysurus*, which in my opinion must be the *Ceratopyge* beds of the country. They are succeeded by some seven feet of beds in which limestones with Korrosionsgruppar developed to perfection are interbedded with thin shales which yielded me ill-preserved *Shumardia*, and with them such indications of graptolites that I was compelled to refer them to the Phyllograptusskiffer above. Wiman, however, in his latest paper, G.F.F.S., November, 1906, has shown that a *Ceratopyge* fauna is developed both here and at several other places in Dalarne.

[1] "Ein Shumardiaschiefer bei Lanna," in Nerike. Arkiv för Zoologi Kglsv. Vet. Akad. Stm., 1905.

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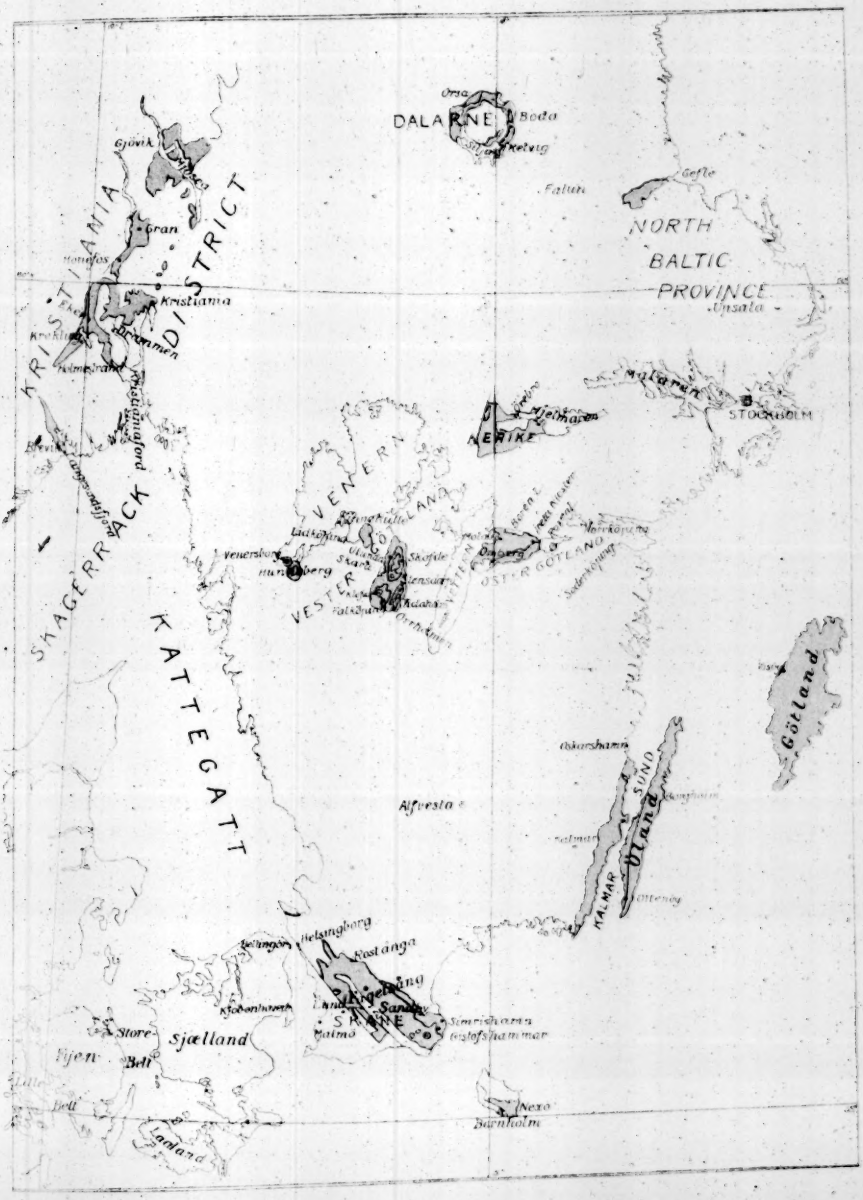
SKETCH MAP OF SOUTHERN SCANDINAVIA
SHOWING THE DISTRIBUTION OF THE LOWER PALÆOZOIC ROCKS.



C. *The Didymograptus Shales and Orthoceras Kalk.*

Coming now to deposits which all are agreed to place within the Ordovician system, I can add but little to what has been already published. The graptolitic equivalents of the Arenig or Skiddavian groups of England have been ably discussed by Professor Törnquist in Sweden[1] (G) and by Dr. Lapworth and Miss Elles[2] in this country. The present generation of Swedish geologists (S 1) seems agreed in calling these by Moberg's name, the Didymograptusskiffer (S 5), just as it also unites the graptolitic equivalents of Llandeilian and Caradocian under Törnquist's Dicellograptusskiffer. Graptolitic deposits are, however, not the only type of Ordovician sediments in Scandinavia, and though in Kristiania, Hunneberg, and the greater part of Skåne the lower half of the Arenig is wholly graptolitic, the calcareous deposits of the more eastern provinces must not be forgotten. These limestones have long been known as the Orthoceras kalk or *Orthoceras* limestone, but until comparatively recently they have only been classified by their colour, and the fact that they come in at lower and lower horizons as we pass eastward until in Oland they represent the whole of the lower as well as the middle and upper Arenig seems to have been overlooked. Taking these calcareous deposits first, we may note the modern palæontological classification due to Möberg and applied by Hedstrom & Wiman (O 1) to the island of Oland—

Ancistroceraskalk, with a Llandeilo trilobite fauna.

Centauruskalk, with *Illaenus centaurus*, *Oggygia dilatata*, etc., and *Didymograptus geminus*.

Platyuruskalk, with *Asaphus platyurus*, *Echinosphærites*, *Lituites*, and many trilobites.

Gigaskalk, with *Megalaspis gigas*.

Upper Asaphuskalk, with a rich but undescribed fauna of small trilobites, *Orthoceras* tolerably common.

The Sphæronite Bed, built up of *Sphæronites punctum*.

Lower Asaphuskalk, with an exceeding rich fauna, including some 24 species of trilobites and a *Phyllograptus*.

Limbatenkalk, with many *Megalaspis limbata*, *Endoceras*, *Orthoceras*, Gasteropods, etc.

Planilimbatenkalk, with *Megalaspis planilimbata*, *Niobe*, *Symphysurus*, and several other genera common to the Ceratopygekalk, into which it passes.

The corresponding classification of the graptolitic deposits due to Törnquist (G) and applied by Törnebohm & Hennig (S 1) to the rocks of Skane is—

Upper *Didymograptus* shales:—

(*b*) Zone of *Didymograptus geminus*, in which Diprionidian graptolites become abundant;

(*a*) Zone of *Phyllograptus* cf. *typus*, in which Diprionidian graptolites are very rare;

[1] "Nagra anmärkningar om vestra Europas Kambriska och Siluriska Kordeli": G.F.F.S., 1889, p. 299.

[2] G. L. Elles: "The Graptolites Fauna of the Skiddaw Slates" Q.J.G.S., 1898, p. 163; "Some Graptolite Zones in the Arenig Rocks of Wales," 1901, Graptolites, parts 1 and 2 (Pal. Soc.).

Lower *Didymograptus* shales:

(*d*) Zone of *Isograptus gibberulus* (Nich.), with *Azygograptus suecicus* and *Didymograptus hirundo*;

(*c*) Zone of *Phyllograptus densus* (Tqt.) = *P. angustifolius*, with *Didymograptus praenuntius* and many long range species;

(*b*) Zone of *Didymograptus balticus* (Thg.), with *D. vacillans*, *D. filiformis*, and many other species;

(*a*) Zone of *Tetragraptus phyllograptoides* (Linrs.), with *D. undulatulus*, *D. geometricus*, *D. constrictus*, etc.;

the lowest member of which passes down also continuously into the Ceratopygekalk. Owing to the interstratification of the Orthocerkalk of Scane between the lower and upper *Didymograptus* shales it is probable that the time value of these various zones is somewhat unequal. According to Hennig (S 1) it is probable that the limestone belongs wholly to the *Gibberulus* zone, and as it would seem that it represents some part of the Limbatenkalk and Lower Asaphuskalk of Öland, it must follow that the lower zones *a*, *b*, and *c* are together the equivalent of the Planilimbatenkalk and lowest Limbatenkalk only.

In Vestergötland we obtain further evidence in the same direction, and, further, are able to follow the easterly thinning of the graptolite beds most beautifully. At Hunneberg only dark graptolitic shales occur beneath the trap, and these to a thickness of about 35 feet represent the two lowest zones with *Tetragraptus phyllograptoides* and *Didymograptus balticus*. At Kinnekulle the shales are greener, but here it is found that the 32 feet measured includes the zone with *Phyllograptus densus* as well as the two lower zones. Here too it can be seen that the *P. densus* zone passes up by alternations into the glauconitic base of the local Limbatenkalk. At Klefva in Western Falbygden only 10 feet of shale overlies the Ceratopygekalk, which is here reduced almost to a line, while at Varnhems, Kloster, and Skultorp, only a little further east, only some 18 inches of shale is seen, and at Sköfde and Ekedalen the recognition of graptolite shales as partings among the limestone seems to be purely theoretical.

In Dalarne the conditions are exactly comparable with those in Vestergötland, but here the replacement of graptolite deposits by limestones follows a north to south rather than a west to east direction, Skattungbyn being comparable with Kinnekulle, while Rättvik is very like Skultorp or Ekedalen. The *Orthoceras* limestone of Boda in this district is interesting in that, like the Leptænakalk of Rättvik, it occurs as the core of a sharp anticline, and has taken on the crystalline structures characteristic of the so-called knoll reefs.

About Kristiania the graptolitic facies is exceedingly well developed (10–80 feet) (K 1), and the calcareous facies comes in at an horizon somewhat higher than at any Swedish locality. Unfortunately the subdivision of these shales, 3*b* of Brögger, has not been worked out, but their highest bed seems to contain the equivalents of the *Didymograptus bifidus* zone of Arenig. Again, the overlying Megalaspiskalk (3*c a*) belongs to the Limbatenkalk, the Expansusskiffer (3*c γ*) being equivalent to the Öland Asaphuskalk, and the 'true' Orthocerkalk (3*c γ*) to the Gigaskalk of the same district. Higher beds in this

district become shaly, and with *Ogygia dilatata* and other Llandeilian forms contain *Didymograptus geminus*.

The Boundary between Cambrian and Ordovician Systems.

Summarily, then, we may say that the main stratigraphical features of the Scandinavian Tremadoc and Arenig rocks are inconsiderable thickness and heterogeneity. Their lowest beds, like other members of the Alum Shale Series, preserve a character so uniform that beds hardly more than a foot thick can be recognized in districts five hundred miles apart. The question of the contemporaneity or otherwise of *Dictyonema* shales with parts of the *Ceratopyge* shales remains, but the equivalence of *Dictyonema* shales and *Obolus* conglomerate seems practically certain. The existence of the *Obolus* conglomerate interstratified among *Dictyonema* shales, the break between *Dictyonema* or *Ceratopyge* shales and overlying glauconitic beds, and the numberless lines of contemporary erosion within the latter, all seem to preclude the possibility of any of these beds having had a truly deep-water origin. The wide distribution of individual species of organisms and the comparative thinness of the beds must, on the other hand, most certainly point to a state of great uniformity, and possibly to very open-water conditions. The replacement of the graptolitic Arenig mudstones of the west by the comminuted calcareous organic deposits which form the eastern limestones with their ripple-marks and worm-tracks is further evidence in the same direction, and would seem to show that the eastern districts were at that time areas of considerable tectonic instability. All these stratigraphical considerations have doubtless had their influence in determining for the Swedes, who in such matters are essentially a nation of palæontologists, at what horizon they shall separate the first or Cambrian from the second or Ordovician system, and as the facts have accumulated but slowly, a settlement of the question has been equally gradually evolved. A brief historical summary of the process may perhaps be of interest.

In 1854 Angelin,[1] following Barrande's idea that geological systems are to be defined as definite stages of palæontological evolution, determined that rocks containing a predominance of Olenid trilobites shall in Sweden be termed Cambrian, while those with a corresponding abundance of Asaphids shall belong to the Lower Silurian (Ordovician). In 1869 Linnarsson (W 1) further developed the same idea, and placed the "Regio Ceratopygarum" within the Ordovician. About the same time also Linnarsson began to make use of the graptolites to mark subdivisions within systems already constituted, and in so doing decided to group the *Dictyonema* beds, which at that time were not known to contain trilobites, with the lithologically similar Alum Shales of the Cambrian. In 1881 Brögger (K 1) in Norway, following Kjerulf and Linnarsson, placed the Ceratopygekalk (*3a γ*) within the Ordovician, and on the evidence that underlying *Ceratopyge* shales (*3a β*) and beds with *Symphysurus incipiens* (*3a α*) both contain Asaphid trilobites, grouped the three together as *Ceratopyge* beds at the base of the Ordovician, and again left the *Dictyonema* beds as the highest

[1] N. P. Angelin: "Palæontologia Scandinavica," 1852, 1854.

member of the Cambrian. In 1890 Moberg,[1] having found the *Dictyonema* shales of Oland passing upwards imperceptibly into *Shumardia* shales with *Ceratopyge* fauna, tried to include these *Ceratopyge* shales along with the *Dictyonema* beds in the Cambrian, and to begin the Ordovician above the lithological break or unconformity at the base of the Glauconiteskiffer. More recently, however, he discovered the bands of Alum Shales with *Ceratopyge* shale fauna interstratified among Ceratopygekalk above the break, and having also in 1898 discovered the Ordovician types of trilobites within the *Dictyonema* shales of Sandby (83), has been compelled to abandon that view. In 1900, therefore, he states (04) that the *Dictyonema* shales are merely a graptolitic facies of the Ceratopygeskiffer, and as such must with them be included within the Ordovician. This seems, moreover, to be the view now held by all Scandinavian geologists, and if we can agree (1) that there are no true natural boundaries of worldwide application, (2) that geological systems at first broadly suggested may become on further knowledge mere matters of convenience, (3) that the best boundaries are those conventional faunistic lines which are most easy to define and trace, we too shall probably adopt the same. By adopting the *Dictyonema* horizon we give ourselves the opportunity of utilizing to the full the earliest known readily recognizable fossil of pelagic and probably planktonic habit which is known to be preserved among all classes of sediment and in many and distant parts of the world, while by grouping the *Dictyonema* beds with the Ordovician we exclude any considerable developments of graptolites from the Cambrian, and place a horizon which for multitudinous profusion of graptolite individuals is unsurpassed in the system of graptolitic predominance. If, however, we continue to maintain that the old ill-constituted Tremadoc Slates must remain a series either at the top of the Cambrian or base of the Ordovician we become involved in all sorts of difficulties, and are quite unable to ascertain any corresponding boundary either up or down among these well-studied Scandinavian rocks.

Comparison with British Rocks.

Having now stated generally the main features of the Scandinavian Cambro-Ordovician succession, I propose briefly to compare our British rocks with the corresponding members of that succession, and in so doing will consider British rocks also in the order of their superposition.

The newest Welsh rocks comparable with the Alum Shales are the Upper Dolgelly Group[2] or Black Band of the Upper Lingula Flags. These include the zone of *Sphærophthalmus* and *Orthis lenticularis* below and the zone of *Peltura scarabæoides* above. They are not more than ten times as thick as their Scandinavian equivalents, and except for cleavage and absence of calcareous (orsten) material might very well be the hardened representative of beds with Scandinavian lithology. Their faunistic assemblages and succession are also similar, and they preserve their character unchanged along the whole of their

[1] "Om en afdelning inom Olands dictyonemaskiffer saisone motsvarighet till Ceratopygeskiffern in Norge": S.G.U., ser. C, No. 109.

[2] Belt: Geol. Mag., 1867, p. 538.

known outcrop. The less altered Upper Black Shales of Malvern[1] and the Upper Oldbury Shales of Stockingford[2] are even more Scandinavian in aspect.

The Lower Tremadoc Slates[3] or *Niobe* beds,[4] on the other hand, have nothing in common with any Scandinavian rock I have seen. They occupy the stratigraphical position of the *Acerocare* zone of that area, but are not known to contain any of the fossils characteristic of that zone. As discussed in my Arenig paper,[5] the change of lithology at their base is very abrupt, and in the absence of other evidence may, I think, have brought the new Asaphidian fauna into power in Britain before the corresponding displacement of Olenids took place in Scandinavia. It was for this reason that I sought so carefully and laid so much stress upon the discovery of the Asaphidian genera *Niobe*, *Symphysurus*, and *Megalaspis* within the middle and upper parts of the *Acerocare* zone of Sandby, Jerrestadt, and Krekling, and I claim that the existence of these genera at such a horizon puts the stratigraphical correlation of the *Niobe* beds of Britain with the *Acerocare* zone of Scandinavia upon a firm palæontological basis.

The *Obolus* bed mentioned in my discussion of the Shineton Beds of Penmorfa[6] and there grouped with the Lower Tremadoc is very like the *Obolus* sandstone at the base of the *Dictyonema* shales of Östergötland, and is better considered as the basal member of the British *Dictyonema* shales.

The *Dictyonema* shales of Wales have a lithology which is unlike any of the Scandinavian *Dictyonema* rocks. The Tremadoc *Dictyonema*[6] in the Cambridge Sedgwick Museum collection, like my own from Arenig and Dolgelly, have their cells very badly preserved, but on the whole are *Dictyonema* rather than *Dictyograptus*. Their characteristic grouping in radiating colonies of four or six individuals is not well seen in any of the Scandinavian museum specimens, but is strongly suggested in the ill-preserved examples from the lowest *Dictyonema* beds of Krekling and Sandby, and I am of opinion that the Welsh *Dictyonema sociale* represents a very low horizon within the *Dictyonema* series. The Mary Dingle (Shropshire) specimens seem to be of *D. flabelliforme* type, while the Pedwardine and Bronsil shale specimens of Malvern include both low and high types. The Merivale specimens, so far as I know them, are indeterminate.

Of other graptolites we may probably consider the *Clonograptus* or *Bryograptus* of Shineton as equivalent to the lower *Ceratopyge* shales of Norway and *Clonograptus* and *D. norvegicus* beds of Fagelsång, but of the position of the Barf slabs[7] with *Bryograptus* I do not feel so certain.

The main fossiliferous horizon of British Tremadoc rocks, which includes beds just above and just below the Tai Herion Flags of

[1] Croom: Q.J.G.S., 1902, p. 59.
[2] Lapworth, "Geology of Birmingham District": Proc. Geol. Assoc., 1898, p. 357.
[3] Ramsay, "Geology of North Wales": Geol. Surv. Memoir, vol. iii.
[4] Fearnsides: Q.J.G.S., 1905.
[5] Rep. Brit. Assoc., 1902, p. 614.
[6] *D. sociale*, Salter: Appendix to Ramsay's "Geology of North Wales" (Geol. Surv. Memoir), vol. iii. pp. 331.
[7] Marr: Geol. Mag., 1894, p. 122.

Arenig,[1] the Belswardine locality at Shineton,[2] and the Pen Moel Post Office beds[3] near Tremadoc,[4] has much in common with the highest Ceratopygeskiffer of Kristiania. The fact that they also yield *Dikellocephalus*, *Cheirurus*, and *Ampyx*-like forms, however, also connects them with the true Ceratopygekalk, and on the whole we may say that they belong to the horizon where *Shumardia* is most abundant.

Of the Upper Tremadoc Slates[4] with *Angelina*, which are known only about the Tremadoc estuary, I can say little, except that, like the *Niobe* beds below, they are totally unlike any Scandinavian series I have seen. As, however, in Wales they overlie the *Shumardia* horizon and have a considerable thickness we must conclude that they too represent some part either of the upper Ceratopygekalk or of the basal portion of the Planilimbatenkalk, but, if so, difference of lithology must account for a very great difference in fauna.

The *Oggygia marginata* and *Peltura punctata* beds of Caermarthenshire[5] I am unable to correlate; but would suggest that the *Oggygia* is probably a *Megalaspis* and is not very like any known Tremadoc or Ceratopygekalk form. The *Nesuretus* beds of Dr. Hicks[6] also have more in common with the Lower Asaphuskalk of Eastern Sweden than with any older bed.

The unconformity which separates Tremadoc from Arenig rocks in North Wales corresponds to some extent to the break which separates *Dictyonema* or *Ceratopyge* shales from the Glauconitic beds and Ceratopygekalk in Eastern and Central Sweden, but occurs, I think, at a higher horizon.

Of reputed Arenig rocks the graptolitic beds have been compared in detail by Miss Elles[7] with the *Didymograptus* shales, and it will here suffice to mention that among these Skiddaw Slates we have the only known British equivalents of the zone of *Tetragraptus phyllograptoides* and a possible continuous passage up from the Tremadoc. In Wales the lowest Arenig horizon is not lower than the upper part of the zone of *Didymograptus balticus*, and in North Wales probably comes within the *Phyllograptus* cf. *densus* zone. The upward succession above this is continuous, and can be checked zone by zone by means of its graptolitic bands. The trilobite beds, like those of the Tremadoc, are not so comparable, and their ashy constitution seems to have had great effect upon the faunas which have little in common with those of the trilobitic *Orthoceras* limestone. The Erwent Limestone[8] of Arenig and the *Nesuretus* beds of South Wales[9] have, however, a general aspect not unlike the Asaphuskalk of Oland.

For more general comparisons I will refer readers to parts i and ii of the new monograph of the Swedish *Ceratopyge* region by Moberg

[1] Fearnsides: Q.J.G.S., 1905.
[2] Callaway: Q.J.G.S., 1877, p. 652.
[3] Fearnsides: Rep. Brit. Assoc., 1902, p. 614.
[4] Ramsay, "Geology of North Wales" (Geol. Surv. Memoirs), vol. iii.
[5] Crossfield & Skeat: Q.J.G.S., vol. lii (1896), p. 525.
[6] Hicks: Q.J.G.S., p. 39, vol. xxix.
[7] Elles: Geol. Mag., 1904.
[8] Fearnsides: Q.J.G.S., 1905.
[9] Hicks: Q.J.G.S., vol. xxix, p. 39.

TABLE TO SHOW THE DISTRIBUTION OF THE VARIOUS SUBDIVISIONS OF THE ARENIG AND TREMADOC ROCKS OF SCANDINAVIA.

	Subdivisions based upon the Distribution of the Graptolites.	Kristiania.	Skåne.	Hunneberg.	Kinnekulle.	Fallbygden.	South Oland.	North Oland.	Östergötland.	Närke.	South Dalarne	North Dalarne	Subdivisions based upon a Study of the Trilobites.	
		T	T	...	T	T	T	T	T	T	T	T	Centaurus-kalk.	LLANDEILO
	Zone of *Didymograptus geminus* ...	G	G	...	...	...	...	...	...	...	...	...		
		T	...	...	T	T	T	T	T	T	T	T	Platyurus-kalk.	
	Zone of *Phyllograptus* cf. *typus* ...	G	G	...	...	...	...	...	...	...	...	...		
		T	...	...	T	T	T	T	T	T	T	T	Gigas-kalk.	
		T	...	...	T	T	T	T	T	T	T	T	Upper Asaphus-kalk.	
		T	T	...	T	T	T	T	T	T	T	T	Lower Asaphus-kalk.	
ARENIG	Zone of *Isograptus gibberulus*	G	G	...	...	...	...	...	...	...	...	...		ARENIG.
	Zone of *Phyllograptus angustifolius* ..	T G	G	...	T G	T G	T	T	T	T	T	T G	Limbata-kalk.	
	Zone of *Didymograptus bifidus* ...	G	G	G	G	...	...	...	...	...	G	G		
		...	...	...	...	T a	T	T	T	T	T	T	Planilimbata-kalk.	
	Zone of *Tetragraptus phyllograptoides*	...	G	G	G	...	...	...	...	...	...	...		
		T	...	T	T	T a	T	T	T	? T	T	T	Beds with *Apatocephalus serratus*.	
		T	T	T	a	a	T	a	a	a	a	a	Beds with *Lotzia*.	
	Zone of *Bryograptus Kjerulfi*	T G	T G	a	a	a	T G	T G	? a	? a	? a	a	Beds with *Shumardia*.	
	Zone of *Dictyonema norvegica* ...	G	G	...	...	...	...	...	...	...	...	...		
TREMADOC	Zone of *Clonograptus tenellus*	G	G	? a	...	...	G	G	G	...	...	...		TREMADOC.
	Zone of *Dictyograptus flabelliformis* ...	G	T G	G	a	G	G	T G	T G	T G	T G	a	Beds with *Hysterolenus Törnquisti*.	
	Zone of *Dictyonema sociale*	G	G	G	...	...	...	...	G	...	...	...		
		T	T	(T)	a	(T)	T	a	a	? a	a	a	Beds with *Acerocare micropygum*.	
		T	T	(T	a	(T)	(T	a	a	? a	a	a	Beds with *Parabolina heros*.	
		T	T	(T)	a	(T	(T)	a	a	? a	a	a	Beds with *Acerocare expse*.	
		T	T	T	? a	T	T	T a	T	T	a	a	Zone of *Peltura scarabaeoides*.	CAMBRIAN.

NOTE.—The letter T indicates that the sediments are of shelly or trilobite-bearing type.
The letter G indicates that the sediments contain graptolites of the species indicated.
The letter a indicates that sediments of this age have been proved to be absent.
Parentheses are used to show that the sediments of this age, though probably present, have not yet been distinguished.

and Segerberg so often alluded to above (C), and to the suggestive papers by Brögger on the *Eulomia Nicbe* fauna,[1] and by Rudemann on the *Dictyonema* shales of New York State.[2]

In conclusion, therefore, I maintain that within the Cambro-Ordovician transition series of Britain and Scandinavia we are able to recognize with certainty the following common horizons—(E) zone of *Isograptus gibberulus* = zone of *Didymograptus hirundo*; (D) zone of *Didymograptus balticus* = base of zone of *Didymograptus extensus*; (C) base of Ceratopygekalk = *Shumardia* beds; (B) base of *Dictyograptus* shales = zone of *Dictyonema sociale*; (A) zone of *Peltura scarabaeoides* = zone of *Peltura scarabaeoides*; but that no one of these marks any distinctive forward step in the evolution of the trilobites. If trilobites must be retained as the basis of systematic classification, it becomes necessary to begin the Ordovician system somewhere within the *Acerocare* zone of Sweden and at the base of the *Niobe* beds of Britain. This, however, I think would be quite unsatisfactory, and I would urge that instead we follow the lead of the Scandinavian geologists and agree to separate the Cambrian and Ordovician systems in such a way that the *Dictyonema*-bearing beds may be included with the rest of the graptolites within the latter.

III.—North Norfolk Geology: The Chalk and its Dislocation.

By Sir Henry H. Howorth, K.C.I.E., F.R.S., F.G.S.

(*Concluded from the June Number, p.* 277.)

MR. CLEMENT REID'S explanation of the broken and contorted condition of the Chalk seems to me quite incomprehensible. Let us analyze the position rather more closely. The champions of ice as the cause of the phenomenon we are discussing appeal to it in two forms—ice-sheets and icebergs. Mr. Reid was, I believe, the originator of the notion that the dislocations of the Norfolk Chalk were due to an ice-sheet, which means an ice-sheet occupying the North Sea.

I should like to quote a sentence or two from the Survey Memoir on the country round Cromer in support of this statement. We are there told that "at Trimingham the chalk has been forced *by glacial action* much above its normal height" (op. cit., p. 3). Again, speaking of the difficulty of ascertaining the entire thickness of the Cretaceous rocks at Trimingham, we read, "Owing to the disturbance from *glacial action* and other causes no very satisfactory dips can be obtained on the coast" (op. cit., p. 5).

On p. 82 of the same memoir Mr. Reid claims that he was the first who, in 1880, suggested that the disturbances in question were caused by the pressure of *the ice-sheet*, which, during the greatest intensity of the cold, probably filled the bed of the North Sea and ploughed up large masses of chalk, driving them laterally into the beds (Geological Magazine, 1880, pp. 55–66). This view was still

[1] Nyt Mag fur Naturvidensk. Kristiania, 1896.
[2] New York State Museum, Bull. 69, p. 934, 1903.

maintained by Mr. Reid in his Survey Memoir, in which he urged that it was the only one which would fully explain the facts (l.c., p. 114).

The postulate of a North Sea ice-sheet seems to me, as it has always seemed to me, the most stupendous unverified and unverifiable premise that the great adepts in such postulates, the glacialists, have produced. As a physical fact, and even possibility, it is absolutely scouted by every physicist before whom I have put it for criticism, and this includes some of the most distinguished in these realms; and it is astonishing that, in view of this hypothesis traversing very elementary physical laws, it should continue to be put forward by geologists without the smallest attempt to justify its possibility. Note especially Mr. Lamplugh's extraordinary appeals to it in various ways down to the address he lately gave at York.

It is not only the physicists, however, who object to this particular sample of professedly scientific appeals without scientific justification. Pettersen and other Norwegian geologists have conclusively shown that if there was a North Sea ice-sheet it could not have come from Western Norway, since it is perfectly plain from the distribution of the erratics that the Norwegian ice never even reached the string of islands that fringe the Norwegian coast.

Such an ice-sheet, if it existed at all then, could only have been composed of frozen sea-water like that on ponds and lakes, and like that in the palæocrystic sea, which does not move as a glacier moves. Its crystalline structure is entirely different to glacier ice, and it cannot be made to shear. Here, then, are some very elementary reasons why the North Sea ice-sheet of Glacial geologists has been described as a mere outcome of nursery science.

This makes Mr. Reid's appeal to it as an alternative to the Rev. O. Fisher's appeal to the pressure of superincumbent strata a very inconsequent one. Granting, however, the existence of such an ice-sheet (which I am only prepared to grant as having an imaginary existence in Cloudland), how does it serve Mr. Reid's purpose? He seems to think that an ice-sheet could "exert enormous lateral thrust or a sliding pressure from above." How was this to happen? Nothing can be plainer, and I have adduced abundant proofs which have satisfied physicists in more than one of my works that such an ice-sheet could not move *en masse* over a flat or uneven surface for more than a very short distance. No conceivable impulse to cause such a movement as the theory of the North Sea ice-sheet requires is forthcoming which would not crush the ice into slush and dissipate all its energy. Any movement in such ice-sheets must have been molecular and not a movement *en masse*. How is Mr. Reid to secure his lateral pressure or his sliding pressure from above in a mass of ice moving molecularly and in which the molecules moved over each other at a snail's pace? Perhaps some one who understands how the end could be compassed by the suggested means would explain the process before its possibility was so jauntily assumed. Surely this stupendous premise should have been verified.

To me it is an insoluble mystery how such hypotheses can be treated as science at all. Without Mr. Reid's lateral pressure, ice

would merely act as a mass of considerable ponderability, pressing on its bed like the very strata press which Mr. O. Fisher appealed to, and which Mr. Reid in his case rejects as impossible, with one considerable element to its disadvantage. While it was possible for Mr. O. Fisher to appeal to differential effects on the subjacent chalk caused by a differential pressure of the superjacent strata he has piled up at different levels, how is it possible to make such an appeal in the case of an ice-sheet whose pressure would necessarily be equable and not differential, for its depth and slope would be uniform if it were made in accordance with what the facts require? How, then, could it produce breakages and dislocations in one place and in another pass over fine layers of sand without disturbing them? These are *a priori* objections, the kind of objections which would occur even to a schoolboy, and which ought to be faced before any such theory is applied to explain concrete facts.

Let us, however, turn to these concrete facts. What are the phenomena which the ice-sheet is supposed to explain? First the meandering and wave-like curves of the chalk in certain places. How is an ice-sheet moving molecularly to bend a solid intractable material like chalk into the sinuous and serpentinous folds we find here? It is not merely the formation of these serpentinous folds that has to be explained, however, but if the ice-sheet came from the sea it is their existence at right angles to the line of march of the postulated monster that has to be explained. It is for those who make the appeal to show its reasonableness. Let us now turn from the contour of the chalk to the mode in which its broken masses occur. The explanation of these masses of transported chalk cannot be separated from that of the loose beds in which they lie as they are exposed in the Norfolk cliffs.

It is not long ago since the phenomena presented by the contorted drifts in the Norfolk cliffs were deliberately and positively ascribed to the action of ice. It was ice which had contorted the drift, it was ice which had detached and redeposited the chalk cakes; ice was everywhere, in fact.

The case looks very different now. The first explanation to go was the biological evidence. Everyone, I believe, now agrees with Mr. Horace Woodward that the so-called glacial shells in the drifts on the Norfolk coast are derivative—that they are the fragmentary and *remanié* contents of the underlying Crag beds, which have been further broken during the portage and then distributed through the superimposed clays and sands, and that there are no glacial shells, properly so called, to be found in Norfolk. This view some of us have maintained for a long time, and the champions of the older view that the shells are true glacial shells, which finds a prominent place in some of the Survey Memoirs on East Anglia, are now reduced to quite a small fraction of their former number.

Secondly, in regard to the contorted sands and clays which form the great mass of the drifts in the Norfolk cliffs, it was a heavy blow to the older and wilder school of glacialists when an American glacialist in whose acumen they greatly trusted and whose leadership they gladly followed, namely Mr. Carvell Lewis, threw over the whole hypothesis

in so far as it was directed to explain these East Anglian drifts. He adopted virtually the same views which had long been held about them by other geologists who had the misfortune to be English and to have spent months in their close study instead of making a mere casual and rapid visit in a general survey of the glacial phenomena of the world, quite in the American motor-car style of scientific exploration. He declared quite frankly that he saw nothing in these contorted drifts that had any resemblance to ice action of any kind, and more recent visitors and critics have said the same. These sorted and laminated clays, these sorted and finely laminated sands, tossed and twisted into huge and re-entering curves, have not a single feature in common with the heterogeneous so-called 'muck' (a mixture of clay, sand, and stones) which forms the staple contents of moraines or other ice deposits, and in every cubic inch they bear the unmistakable impress of water action upon them.

It is in the midst of these laminated and twisted and curled clays and sands, all witnessing the action of water in every cubic inch, that we find deposited the cakes and vast polygonal masses of chalk of which I have spoken earlier; and it has been no small proof of the temerity of the glacial prophets that, notwithstanding this patent fact, they should not have shrunk from explaining the detachment of these great masses from their matrix, and their portage to their present surroundings, by means of ice of whose presence the soft matrix in which the chalk masses are embedded does not present a trace, but whose structure and contents are entirely inconsistent with ice action. Many of the more reasonable glacialists admit this fully.

Although they have been stunned and baffled by the overwhelming case against them in regard to the sandy and clayey matrix of the chalk masses, the writers in question still hold on, however, to their *Deus ex machina* in respect to these latter, as if it were possible to attribute the two phenomena, which occur together in an inseparable conjunction, to two entirely different forces acting in an entirely different way and producing entirely different results. The critical test is simple enough.

Granting that at the time when the drifts were deposited the chalk over the greater part of Norfolk was lying horizontally in an unbroken condition at a much lower level than it is now, which I have shown strong reason for concluding, how was an ice-sheet when moving over it molecularly at a snail's pace to break this continuous chalk, and detach from the matrix, the great polygonal masses, the angular fragments, and long ribbons of table-like chalk found in the cliffs? As I have shown at great length elsewhere, modern glaciers do not break up their beds, although they sometimes traverse beds that had been dislocated and broken by other forces long before the glaciers were there. *A fortiori* would the quite hypothetical ice-sheets fail in such work, since their motion was *ex hypothesi* so much more slow and so much more molecular in character than that of icebergs, for they had no slopes to give them impulse and their dynamical energy would virtually be reduced to zero when they were planted on flat or uneven surfaces.

We must remember that, whatever the cause, the broken chalk in

most cases shows no signs of crushing or pounding, but only of actual fracture by impact. The masses of chalk are angular, and have raw and unworn edges, the result of forcible tearing and not of crushing, and the chalk with its layers of flint are quite intact from end to end on the chalk cakes. It defies every suggestion available to me how these vast polygons with torn sides and edges (not detached along lines of bedding or of old joints, but right across the solid chalk and the flints it contains) should have resulted from any form of pressure, whether perpendicular or acting laterally. It is even more difficult to understand how the long fragile thin slabs and tables of chalk I call chalk cakes (which are in places still covered by their original covering of Crag, which have irregular edges, and have their lower surfaces with great pieces scooped out as if bitten out by some primæval ogre) could have been detached by any instrument of the character and mode of motion of an ice-sheet.

If the case for causing the breakage and dislocation in question is hopeless when it is an ice-sheet passing directly over the surface of the chalk itself which is postulated, how much more so does it become hopeless when the chalk was covered over and padded with a widespread soft cushion of Crag sands and clays, through which it would be impossible for the requisite dynamical forces to be conveyed at all, much less conveyed without disturbing the lamination of the superincumbent Crag beds?

The breakage and detachment of the chalk masses and chalk cakes from their matrix is not, however, the only puzzle in these cases which seems utterly to baffle all the ingenuity of the orthodox geologists to deal with it. A much greater difficulty exists in explaining the removal, the lifting up to great heights, and the redeposition, as we find them in the contorted drifts of these cliffs, of these masses and cakes of chalk.

There is a small school of glacialists who have absolutely forsworn all appeals to elementary physics, who have argued that vast sheets of ice moving very slowly over enormous distances of flat or uneven ground can not only break up their beds but drag up out of their sockets the débris they have formed, like a dentist drags teeth out of our unwilling gums. This tooth-drawing process is a postulate quite after the fashion of glacialist logic. I have examined and criticized it at length in my two last works. What I wish to say here is that even if small angular boulders or polygonal blocks could be thus extracted from the beds on which they lie by a mass of ice which is meanwhile pressing down on them with the weight of many tons to the yard (a process like that of a man lifting into mid-air the chair on which he is sitting), it is surely beyond the reach of the wildest credulity to suppose this could be done with cakes of chalk several hundred yards long, or vast polygonal masses in which chalk quarries have actually been opened. The whole process seems a mechanical nightmare, and it passes human understanding how men have dared to enunciate it as a rational scientific explanation of these difficulties. The mere dragging out of their matrix and detachment of the chalk masses, however, is not all that has to be explained. They have been carried in some cases far from their original site, and in all cases seem to have been carried some distance and redeposited.

This portage and redeposition are assuredly the most insoluble cruces of all to the champions of "omnipotent ice." Granting that the chalk was broken and the pieces lifted from their sockets by some force or other, how could ice take up these vast masses and fragile slabs of chalk, with sand and gravel attached to them, still retaining their original delicate lamination? First, as to the portage. When a glacier carries stones like some of these angular chalk masses (which, be it remembered, are of every shape and size down to the smallest chalk rubble), it can only do so on its back. It is thus the angular erratics of Greenland, Norway, and Switzerland are being carried now. But in all these cases there is no difficulty in accounting for the presence of the blocks on the back of the glacier. They have in all cases been detached from peaks projecting above the ice, and have rolled down upon its back. The present case is very different. There is no question of projecting peaks of chalk detaching portions of themselves, and of these detached pieces rolling down upon the ice, for, as we have seen, when they were formed by the breakage and dislocation of the chalk beds those beds were covered with Crag containing unweathered shells still *in situ*, showing that they were lying at the bottom of the sea. How could an ice-sheet traversing the North Sea (if such a postulate is possible out of a nursery story) transfer from the bottom of that sea to its own back great cakes of chalk still covered with shelly Crag beds, and with their long bodies uncracked and intact, is indeed a puzzle: as great a puzzle as it would be to push a number of eggs through the steel plate of an ironclad without breaking their shells or disintegrating their yolks.

If the ice-sheet did not carry the chalk cakes and other débris on its back, but underneath it, as the advocates of *moraines profondes* argue, the puzzle seems even greater, for it could hardly fail to roll the smaller masses and to round the angles of all. There is virtually no rounding or weathering visible, however, but all are intact. Such portage, again, would scrape off the Crag which covers some of them, and would break up its contained shells into powder, for it is clear that if ice can move stones underneath its bed *when travelling over level ground*, which I dispute, and have written a great deal to disprove, it can only have done so by its lower layers dragging along the débris underlying the ice. Such a process, when all movement in the ice was molecular only, and the pace so slow that its rate is not appreciable to the senses, seems, however, quite incredible. Where the motive force was to be derived from to enable a very intangible internal movement of ice particles in an ice-sheet to move along vast masses of chalk many thousands of tons in weight, by dragging them underneath its mass, is incomprehensible to me. That it should have done so without rubbing down the sharp edges of these masses, or in some measure weathering them, and should not have stripped them of their adherent layers of finely laminated and loosely aggregated sands with delicate shells in them, without destroying either laminations or shells, may be pronounced impossible until some glacialist has had the courage and frankness not merely to shoot a wild hypothesis at our heads but to reconcile it with common-sense.

In every way the problem is faced; therefore, whether on *a priori*

grounds or inductively, the explanation of the phenomena presented by the dislocation of the Norfolk Chalk by the agency of land ice utterly fails.

Let us now turn to the iceberg theory, which still has some powerful advocates. How icebergs could arise in the North Sea I have never been able to realize, for the Norwegian geologists have virtually shown that they could not have come from Western Norway. Nor do I know, if they could, how the necessary marine currents could have arisen to drive them hither instead of choking the English Channel with them, of which fact, if it ever happened, there ought to be some evidence, and I know of none. The former existence of icebergs in the North Sea is, in fact, a mere unsupported hypothesis and one traversing all probabilities.

Granting the possible existence of icebergs in the North Sea, how are we to explain the dislocated chalk of Norfolk by them?

First, as to the actual bending of the chalk into its serpentinous folds in some places and its breakage in others. How these phenomena are to be traced to iceberg action I have never seen explained. When icebergs are floating they cannot of course reach the bed of the ocean to break or dislocate it. When they come to anchor in shallow water, as they do sometimes, they do not rise and fall with the tide. They are much too heavy to do that, so that bumping by icebergs is not to be thought of. All that they can do in the dynamical way is to rock to and fro; but this process, or even bumping if it were possible on a slight scale, would not roll the chalk *in situ* or the chalk cakes into meandering curves, nor detach these vast polygonal masses as big as churches from a solid matrix many hundreds of feet thick, nor would or could it similarly detach ribbons and cakes of chalk requiring an enormous tearing force; *a fortiori* would it fail to do this when the masses and cakes of chalk were covered with the laminated sands and clays of the Crag and yet not disturb their lines of deposit, and under any circumstances the detached masses would not be unweathered and unworn as we find them. Nor can we in this behalf overlook the very wide extent of country over which these detached chalk masses have occurred, not only very far from the present sea but very far from any probable sea margin in Pleistocene times.

Suppose the breaking of the chalk were explained, the detachment of the great masses from their matrix by tearing them up by the roots out of their sockets seems an utterly impossible process to attribute to icebergs, which under certain conditions may squeeze and press with great force but cannot simulate the tooth-drawing process.

Lastly, how were icebergs to convey the masses when broken and detached? Icebergs cannot gather up material which lies beneath them and transport it. When in water their temperature is too high to enable them to be frozen fast to their unstable anchorage. The only way we can suppose that the vast and most fragile ribbons of combined Chalk and laminated Crag were gathered up by icebergs is either that they squeezed them into their substance by pressing on them, which they could not do without crushing their delicate arrangement, or carried them on their backs; but how is it possible for submerged masses of chalk detached from chalk beds lying at the bottom of the

water where the icebergs were floating to be lifted on to the back of any iceberg? A notion that has been gravely propounded, namely, that they rolled down from exposed cliffs, ignores the wide area of inland country far from any coast where they occur, and the utter want of evidence that there were either cliffs or scarps of chalk available from which the masses could have been detached. On the contrary, as we have seen, the most notable of the chalk masses, namely, the chalk cakes, still have the remains of the Crag sea in which they lay attached to them, and we have no evidence whatever that any of the Chalk in Norfolk was above the sea-level when the dislocation took place.

It seems plain, in fact, that ice in any form, either as an ice-sheet or as icebergs, could not have dislocated and distributed the chalk masses as we know them. The hypothesis is at every point inconsistent with the facts.

This virtually means that no known cause acting from above the Chalk was competent to produce the observed effects, and we are necessarily limited to the only alternative cause, namely, some subterranean force of great energy. Such a force is the one whose destructive ruin we so often witness on a limited scale in contemporary earthquakes. As has been shown, earthquakes are marked by actual waves of energy passing through the solid ground, as similar waves pass through the water, and which have the tendency and result when the energy is sufficiently potent to curve the strata through which they pass into a series of anticlinal and synclinal curves, such curves, in fact, as we find in the Chalk of Northern Norfolk and as we find on a much greater scale in the North and South Downs. While this particular phenomenon of the present contour of the Norfolk Chalk seems quite inexplicable by any exercise of force from above, it seems completely explainable by those earth-waves which accompany earthquakes, and to which the most orthodox geologists are quite anxious to appeal when it is a question of explaining the arched, twisted, and torn condition of the crystalline rocks of primitive times. It seems extraordinary that professed Uniformitarians should be so loath to apply the lessons of those early geological times to the Pleistocene age.

The result of such a movement in dense beds of stratified material like chalk must, when the tension was sufficiently great, have caused a vast breakage of the beds, and the broken masses would have the raw edges and torn surfaces we notice in the chalk masses. Not only so, but it seems to me it is the only conceivable way in which the tabular masses of chalk with the stratified material adherent to them could have been detached from the main mass of the chalk. The process would resemble the homely one of the detachment of a concentric layer from an onion by lateral pressure. All pressure or pounding from above must necessarily have smashed up such fragile materials beyond recognition.

So much for the only reasonable explanation of the bending and breaking of the Chalk of Norfolk which, as it seems to me, is available. Let us now pass on to another chapter of the story, namely, that connected with the transport and redisposition of the chalk masses.

As we have seen, the Chalk, when the dislocation and breakage took

place, was in all probability lying horizontally at the bottom of the sea, with the Crag shells living upon it or in its covering mud. If this was so, and I cannot see how the case for it can be answered, it is not merely possible or probable but it is absolutely certain that when the dislocation of the chalk took place vast tidal waves would be caused in the superincumbent sea, similar to but on a much greater scale than the monster tidal waves in the Pacific induced by earth-movements such as are known in Java, South America, and Japan. This I have always maintained.

Granting the existence of these vast tidal waves, which great physicists and mathematicians of the first rank like Hopkins and Babbage freely appealed to as *vera causa* of great dynamical effects in geology, we at once have an efficient cause for the removal and portage of these vast masses of solid material in almost any form or shape or size, the carrying power of water under these conditions being only limited by the quantity and speed of the liquid in motion.

We have no occasion, therefore, to appeal to transcendental ice ages or ice-sheets or to forms of ice acting contrary to all known forms of ice and supposed to have played a quite impossible jugglery with the laws of matter, but we have at our command a perfectly inductive proof supported at every point by the phenomena to be explained, as well as by the known physical qualities of matter.

The *a priori* postulate here involved, as I have said, is consistent with all the phenomena to be explained, and especially with the conditions under which the chalk masses occur in the Norfolk cliffs. The position of these included masses in the soft beds in which they lie makes it plain that the condition of the sands and clays cannot be treated as a separate phenomenon from that of the great masses and cakes of chalk. These latter lie in laminated sands precisely like in character to the laminated sands which overlie them, and neither the laminations above nor below are disturbed. When, again, the great masses of chalk are more or less globular or lenticular in shape, the laminations fold round the outlines of the contained masses, showing that the formation of the laminæ was contemporary with the deposition of the chalk masses. Again, the laminations in the clays and the loams are in places continuous with those in the sands, showing that all the contents of the cliffs form one substantial phenomenon.

What is plain beyond measure is that these laminations could not have been made by any substance so rigid as ice and working in the fashion that ice works either in glaciers or icebergs. Everybody admits that, and I do not know anybody, in fact, who would now argue that the stratification and laminæ in question were due to any other cause but water. Inasmuch as the chalk masses and chalk cakes are found at all levels from the foot of the cliffs to their summit and are found deposited under the conditions already described it is clear that water action, and water action alone, can be invoked for the building up of the bed of which the cliffs afford us a sectional view; and if so, it is plain that the masses of chalk and chalk cakes can only have been carried to where they are found and redeposited by water. It is water alone which could have let them gently settle upon fine stratified beds of sand and clay without disturbing the laminations.

IV.—Australian Paleontologists on Silurian Ophiurids.

By F. A. Bather, M.A., D.Sc., F.G.S.

Some interesting Ophiurids from the Melbournian rocks of Victoria are described by Mr. F. Chapman in Part viii of his valuable series of articles on "New or little-known Victorian fossils in the National Museum" (Melbourne) (Proc. Roy. Soc. Victoria, n. ser., vol. xix, p. 21; Feb., 1907).

First Mr. Chapman gives a fresh interpretation of the fossil originally described by Dr. J. W. Gregory as *Protaster brisingoides* (Geol. Mag., Dec. III, Vol. VI, p. 24; 1889), and subsequently made by him the genotype of his new genus *Sturtzura* (Proc. Zool. Soc. London, 1896, p. 1033; 1897). It appears that the fossil described by Dr. Gregory was an imprint in sandstone, and that the true structure is therefore revealed by a wax squeeze, now taken from a similar imprint. Thus, the ridge described by Dr. Gregory turns out to be a canal, and the ambulacral ossicles, instead of being subquadrate, are really boot-shaped, and, in the opinion of Mr. Chapman, closely approach those of *Protaster bifloris*, Gregory. Mr. Chapman therefore replaces the species in *Protaster*. The specimens studied by Dr. Gregory are in the British Museum (regd. E. 13000–E. 13006). Since no holotype was definitely selected by Dr. Gregory, the original of his figures 1 and 2 (regd. E. 13000), is, with his concurrence, hereby selected. Examination of this and some of the other specimens enables me to confirm Mr. Chapman's interpretation in a general way, though not as regards the precise shape of the ossicles. The paratypes of *Protaster brisingoides* (British Museum, E. 13001–6) probably include more than one species.

Dr. Gregory also referred to his genus *Sturtzura* the species *Protaster leptosoma*, Salter. Mr. Chapman gives a diagram of the arm-structure in this species, based on a specimen from Leintwardine, in the National Museum, Melbourne; and in conformity with Dr. Gregory's interpretation, he regards it as of distinct generic type from *Protaster*. He then proceeds to say that since *Protaster brisingoides*, the type of *Sturtzura*, proves after all to be a *Protaster*, therefore "*Sturtzura leptosoma*, Salter sp., must now be regarded as the type form." Mr. Chapman seems for the moment to have forgotten the perfectly definite, and, one had thought, universally accepted rule of nomenclature, according to which the genus must follow its genotype. In other words, *Sturtzura* must become a simple synonym of *Protaster*. The whole object of fixing on a genotype is to avoid the shifting of generic names, and Mr. Chapman's action in taking Salter's species as the type of *Sturtzura* cannot be justified. If *Protaster leptosoma*, Salter, does not belong to *Protaster*, or to any other existing genus, a new name will have to be found for it.

In describing a closely allied species, under the name *Sturtzura leptosomoides*, Mr. Chapman merely quotes the genus as "*Sturtzura*, Gregory, 1897" (which it no longer is), and makes no attempt to give a fresh diagnosis of it. Some doubt may, however, be cast on his interpretation of the two species which he refers to *Sturtzura* (Chapm. *non* Greg.). Thus, he applies the term 'adambulacrals' to

certain plates apparently distinct from the ambulacrals, and certainly distinct from the spine-bearing plates. Is it not, however, the case that the spiniferous elements are themselves the adambulacrals, and that the elements to which Mr. Chapman applies the term 'adambulacral' are really processes of the ambulacrals, separated from the ambulacral body by a slight depression? Compare my interpretation of *Bundenbachia*, Geol. Mag., 1905, p. 164, Pl. VI, Fig. 5). If, however, this interpretation be correct, then the ambulacral ossicles of *Sturtzura leptosoma* and *S. leptosomoides* are really boot-shaped, as in the typical *Protaster*.

Until someone undertakes a comprehensive revision with proper diagnoses, it will save confusion to retain under *Protaster* all the species here mentioned. None of them, not even *P. biforis*, seems to me congeneric with *P. Sedgwicki*, the genotype of *Protaster*. It may well be that a subsequent reviser may separate *P. brisingoides* with *P. biforis* as one genus, and *P. leptosoma* with *P. leptosomoides* as another. In that event, the former genus will of course resume the name *Sturtzura*.

Mr. Chapman also establishes a new genus *Gregoriura*, with genotype *G. Spryi*, for a Protasterid with triangular ambulacrals, of which the three proximal pairs embrace the mouth-frames. A slender bar extending transversely from the outer point of each ambulacral is called an 'adambulacral' by Mr. Chapman: there are also spine-bearing plates. I would suggest that these elements might be interpreted in the same way as those in '*Sturtzura*' are interpreted above. This would not affect the validity of the genus.

It may be worth while to remind English geologists that in 1899 Mr. R. Etheridge, jun. (Rec. Austral. Mus., vol. iii, pp. 128, 129; 17th April), proposed the name *Sturtzaster* to replace the name *Palæocoma*, which Salter had applied to a starfish from Leintwardine. *Palæocoma* had already been used by d'Orbigny in 1849.

May one, without offending several people of importance, express a hope that the future namer of Palæozoic Ophiurids will endeavour to avoid such combinations as "Mr. Spry's Gregory-tail" or "Mr. Sturtz's tail shaped like Mr. Lightbody"? Whether the object aimed at be humour or euphony, few will seriously consider that either is attained.

V.—Notes on *Metriorhynchus superciliosus*, Desl.

By E. Thurlow Leeds.

The commonest species of the genus *Metriorhynchus* occurring in the Oxford Clay of the Peterborough district is *Metriorhynchus superciliosus* (Desl.). The species found in the above locality has been identified with that of Deslongchamps by the late Mr. J. W. Hulke, F.R.S., in his paper "On the Skeletal Anatomy of the Mesosuchia" Proc. Zool. Soc. London, November 20th, 1888, and also by Mr. Lydekker in the "Catalogue of Fossil Reptilia and Amphibia," part iv, Suppt., p. 252. Mr. Lydekker, at the time he compiled the Catalogue, brought a cast of part of the skull of *M. superciliosus* to compare with the numerous skulls in the Eyebury Collection.

In view of the fact, therefore, that English palæontologists have identified the common species of Crocodile from Fletton, near Peterborough, with *M. superciliosus*, it seems to have been an entirely superfluous and unwarranted proceeding on the part of Dr. E. Schmidt to have given a new name to the species, viz. *M. Jackeli*,[1] especially as he has evidently based his species on the one specimen in the Berlin Museum, and at the same time adduces no reasons for his action. Dr. Schmidt is only adding another synonym to a list that is already long enough.

Dr. G. von Arthaber, in the monograph he has lately published,[2] tries to discover the reasons which led Dr. Schmidt to create a new species, and lays great stress on the shape of frontals and præfrontals and the amount and nature of the conjunction of these bones with one another. He denies that it can be *M. superciliosus* on account of "the laterally strongly prominent and anteriorly pointed præfrontals" ("den seitlich stark vorspringenden und gegen vorn spitz zulaufenden Präfrontialien") which this species possesses. If there is one characteristic which could be applied absolutely literally to the Fletton species it is this one, and one which all the skulls of the common *Metriorhynchus* from the Peterborough district show.[3] Dr. von Arthaber says further that there are at least two varieties, *M. Jackeli* and *M. Moreli*, the former the smaller, the latter the larger type. It would seem that some Continental palæontologists in their desire to discover new species forget to take into consideration such trifles as age or sex in relation to size.

Ten skulls of *M. superciliosus* in the Eyebury Collection show various degrees of length and stoutness, but in all the general proportions are similar, and the sculpture of the frontal bones is identical, though less strongly marked in some than in others.

Mr. Lydekker, in the Catalogue, part iv, Suppl., p. 232, says with regard to *M. superciliosus*: "In the type cranium the præfrontals have only a very short sutural junction with the frontals and a straight inner border, whereas in the type of *M. Blainvillei* of the Kelloway Rock the præfrontals have a long sutural junction with the frontals and a convex inner border. The large series of skulls in the collection of Mr. A. N. Leeds shows, however, such a great variation in these respects that they cannot be regarded as of specific value."

The natural deduction, therefore, is that if these characteristics are unreliable for definitely determining the difference between *M. superciliosus* and *M. Blainvillei*, still greater care must be taken not to create new sub-species of *M. superciliosus*, which shows such variation.

The list of measurements (in millimetres) which I give below is taken from ten skulls practically perfect, except the last one, all in the Eyebury Collection, which I think will bear out my point that while they show for the most part similar proportions, they present here and there curious variations. The explanation of these variations is not

[1] Zeitschr. Deutsch. Geol. Gesellsch., Bd. lvi (1904), Monatsber., p. 97.

[2] "Beiträge zur Kenntnis der Organisation und der Anpassungserscheinungen des Genus *Metriorhynchus*": Beiträge zur Paläont. und Geol. Österreich-Ungarns und des Orients, Bd. xix (1906), p. 293.

[3] Ibid., p. 288.

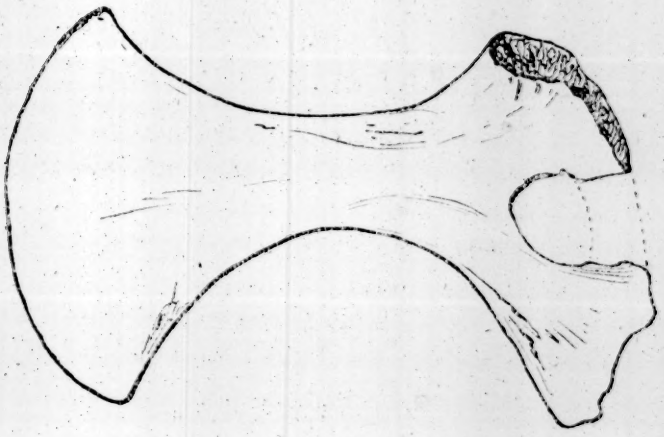
due to crushing, as all the skulls, except one, have been compressed in a similar manner, and therefore only slight discrepancies can be ascribed to this cause.

No.	Length from snout to occipital condyle.	Breadth præfrontals.	Breadth quadrates.	Breadth frontals.	Length præfrontals.	Distance naso-intermaxilla.
6	672	158	190	90	90	72
01	670	151	—	92	88	*c.* 60
163	665	154	185	97	90	80
161	655	141	195	94	90	70
02	637	145	196	88	90	75
162	630	*c.* 146	188	77	90	70
9	580	134	176	87	80	46
8	578	127	175	75	70	*c.* 43
160	578	127	174	71	80	45
Small one	—	98	117	50	50	—
Cast of *M. superciliosus*	—	158	—	100	96	—

No. 162 in the above list is of interest, in that the occipital region of the skull has entirely escaped crushing. It shows a height of 98 mm. to the top of the parietal region. The measurements given by Dr. Schmick, viz., length 650, and breadth between quadrates 190, agree with the above table. I confess I cannot understand Dr. von Arthaber's measurements. The length of the skull, 603 mm., agrees with the skull as figured on pl. xxii, but he gives as the breadth across the præfrontals 176 mm., whereas the figure certainly does not allow of more than 140 mm., which tallies with the above list. The measurements from the point of the nasals to the intermaxilla are somewhat doubtful, as sometimes the points of the bones are not well preserved.

Pectoral Girdle.—In a paper which he read before the Zoological Society of London in 1888, p. 427 ff., the late Mr. J. W. Hulke included a description of the pectoral girdle of *M. superciliosus*, in which, in spite of a protest made at the time by Mr. A. N. Leeds, he described a portion of a coracoid as that of a scapula. This and the bone which he figures, and correctly so (fig. 2), as a coracoid were taken from two different specimens in the Eyebury Collection, both *M. superciliosus*.

In the latter bone there is a submarginal foramen in the portion of the dorsal end anterior to the glenoid facet; in the former the foramen is represented by a deep notch, which separates the articulating portion from the anterior portion, which latter thus forms a projecting process. The notch commences from the point where the foramen is situated in the perforate variety. An imaginary line drawn across the notch from its two corners will show the similarity in the formation of the two bones thus:—



Coracoid of *Metriorhynchus superciliosus* (Desl.). Oxford Clay: Fletton, near Peterborough. From the Leeds Collection, Eyebury, near Peterborough.

That these two bones are really coracoids is proved by the fact that Mr. Leeds has never found four bones of this type with one skeleton of *Metriorhynchus*, although he has several times found the entire pectoral girdle. Further, an examination of associated sets of bones of *Metriorhynchus* at Eyebury and in the Natural History Museum, London, shows that in some cases the coracoid has the foramen and in others the notch, whereas the scapula proper is the same in all cases. Nor can a difference of species be proposed as a solution of this dissimilarity, as these two variants of the coracoid are both found with the common form of *Metriorhynchus*, viz. *M. superciliosus*. Consequently the dissimilarity can only be accounted for by a difference in the degree of ossification, or may be ascribed to chance or to sex.

The mistake which Hulke made has unfortunately been perpetuated in Dr. von Arthaber's monograph,[1] and it seems only right that the proofs given above of this grave error should be published.

Dr. von Arthaber does not stop at this point, but proceeds to include the true scapula in a hypothetical and impossible fore-limb of the animal, a mistake which he could not have made had he compared the scapula at all carefully with the metacarpals and phalanges of the hind-limb, or with the scapula of modern Crocodilia.

It may not be out of place here to give a detailed description of the scapula of *M. superciliosus*.

Scapula.—It is an irregularly-shaped, long, and slender bone, the anterior border being longer than the posterior; the proximal end is triangularly rounded, with a flattened inner surface; the shaft is slender and oval in section. The proximal extremity presents two facets, the anterior one being rugose and triangular, corresponding to a similar facet on the coracoid. These two facets form the articulation

[1] Beiträge z. P. und G. Österreich-Ungarns, 1906, p. 309 ff.

of the scapula and coracoid. The posterior facet is smooth and somewhat irregular in shape; this facet, together with the rounded, slightly concave facet on the coracoid, forms the glenoid cavity.

The distal extremity differs from the extremities of the metatarsals, with which the scapula has been confounded, by the absence of a marked ridge, which always bounds their articulating facets. In the scapula the end of the bone is merely the oral shaft flattened out and rounded off.

Fore-limb.—The fore-limb was small, consisting of the humerus, radius and ulna, and some more small bones, of which the bone figured by Dr. von Arthaber[1] in pl. xxv, fig. 2, is probably one, though he has undoubtedly represented it *upside down*. The limb was not a leg for walking, similar to the hind one, but either a degenerate paddle or an incipient one, as Professor E. Fraas[2] declares it to be in the case of *Geosaurus*, in his interesting work on the marine crocodiles (Thalattosuchia) of the Upper Jura.

Dr. von Arthaber's restoration of the fore-limb is certainly erroneous; for in order to construct it he has had to borrow from other parts of the body, viz. the scapula—which he denies to be such—and the first metatarsal, to form the radius and ulna. The whole leg, as he represents it, is entirely out of proportion to the size of the humerus, which would be incapable of carrying such a limb, and further in no way resembles the fore-limb of *Geosaurus*, which he takes as a model on which to complete the parts of *Metriorhynchus* unknown to him.

All Dr. von Arthaber's remarks must be received with extreme caution, not only on account of the undoubted incorrectness of some of his statements, but also because of the absence of careful observation and editing which his work shows. For example, apart from the errors in regard to the pectoral girdle and fore-limb, which I have already pointed out, in pl. xxiii, fig. 8, he figures a left side rib as one belonging to the right side, and in pl. xxv he calls the pubis the ischium and *vice versâ*, while in pl. xxvi he has them correctly named.

I think it will be of interest in connection with this paper to give a short account of the method of occurrence of the bones found in the Oxford Clay of the Peterborough district. A remark of Dr. von Arthaber's[3] leads me to suppose that he thinks the specimens of *Metriorhynchus* are found in such quantities as to make it hard to distinguish one from another, but this is not the case. The area in which they are found consists of brickyards, extending nearly two miles along the Great Northern Railway from Peterborough to London, and the clay is worked to a depth of 35 feet or more. *Metriorhynchus*, like the other animals occurring in this clay, is found at all depths, and at considerable intervals of time in the various pits. Bones that are termed 'associated sets' are found at the same time, and at the same level, in close proximity, if not in position as the carcase of the animal was buried. If there were any doubt as to their belonging to

[1] Beiträge z. P. und G. Österreich Ungarns, 1906.

[2] "Die Meer Crocodilier (Thalattosuchia) des oberen Jura": Palæont., vol. xlix (1902-3).

[3] Beiträge z. P. und G. Österreich-Ungarns, 1906, p. 302.

one animal, that doubt is dispersed, because it is a self-evident fact that at some time or other more than one bone of the same kind would have been found together; but as this is not so, and as their colour and size agree, the bones, though scattered over a distance of some yards, must necessarily belong to one and the same animal.

In conclusion, I wish to say that a large number of the statements I have made are based on the experience which my father, Mr. A. N. Leeds, has gained during a period of over 40 years in which he has collected from the Oxford Clay of Peterborough, and I am deeply indebted to him for the great assistance I have derived from his experience, and for valuable suggestions which he has offered.

REVIEWS.

I.—The Geology of India.

The Imperial Gazetteer of India. New Edition. Oxford, 1907.

THE first edition of the "Imperial Gazetteer of India" was published in nine volumes in 1881, and a second edition, augmented to fourteen volumes, was issued in 1885–7. The bulk will now be raised from fourteen to twenty-six volumes, including a companion Atlas, and the single volume of the "Indian Empire" has been expanded into four volumes, entitled respectively: I. Descriptive; II. Historical; III. Economic; and IV. Administrative. We propose to notice the chapter on Geology by Mr. T. H. Holland, Director of the Geological Survey of India, in vol. i. p. 50, and the chapter on Mines and Minerals, in vol. iii, p. 128.

1. "Indian Empire," Vol. I, pp. 50–103.—Geology.

Those persons who have paid any attention to this subject are aware that, physically, India consists of three distinct regions, viz., Peninsular India, the Indo-Gangetic Plain, and extra-Peninsular India. A geological map shows this at once, but these features are not equally obvious on an ordinary map. Practically the Indo-Gangetic Plain, with its great alluvial accumulations, separates two regions, which, though markedly distinct in origin and composition, yet afford in each case an interesting geological record, which it is possible to correlate within certain limits. Hence, if we eliminate the deposits of the Indo-Gangetic Plain, the geology of India is a duplicate system, the peninsular belt being without marine fossils, excepting strips along the coast, much resembling Africa south of the Equator in this respect, whilst the extra-peninsular areas in one place or another are able to show an almost complete palæontological column of marine fossils, dating from the earliest Cambrian. It should also be borne in mind that the Peninsula has been a stable area almost from the beginning of geological time, whilst the extra-peninsular region has been one of frequent oscillation culminating in the Himalayan uplift.

Introduction.—Mr. Holland remarks that, in attempting to express these two distinct geological stories in European terminology, we find that our simplest and most easily translated characters are preserved in the marine fossiliferous strata, while it is practically impossible to correlate directly the land and fresh-water formations which are so largely developed on the Peninsula with their equivalent stages in the European standard scale. He also specially points out, by way of illustration, that the flora "which flourished in the great river valleys of the old Gondwāna continent did not make its appearance in Europe until well on in the Mesozoic era, yet, from other evidence, we know that the lowest Coal-measures in India were being formed during Upper Palæozoic times." He further insists upon want of strict contemporaneity in geological formation, and strongly advocates the use of local stratigraphical names.

In the classification of Indian strata there is a trace of a datum-line in the *Neobolus*-beds of the Salt Range, which may be regarded as the equivalents of the *Olenellus*-zone in other Cambrian areas.

To the ages *preceding* the date at which the *Neobolus*-beds were formed he refers—

(*a*) The great mass of crystalline schists which are exposed over half the Peninsula, forming the old floor on which the unaltered sediments were laid down.

(*b*) The great thicknesses of unfossiliferous strata known by such local names as Gwaliors, Cuddapahs, and Vindhyans.

The ages following the Lower Cambrian Period have left their record in two groups—

(*c*) During the Palæozoic era deposits were formed in the extra-peninsular area with fossil remains referable to one or other of the well-known systems of Europe from the Cambrian to the Carboniferous. No records of this era have been preserved in the Peninsula.

(*d*) From Permo-Carboniferous times to the present day we have a double history: a record of life and events on the stable Peninsula, and a series of deposits formed in the adjoining ocean, whose bed was afterwards upheaved to constitute the extra-peninsular parts of India.

Thus Indian rocks fall naturally into *four* great groups: *two* below the *Olenellus* datum-line without fossils, and *two* above the horizon at which the oldest recognizable fossils occur. These four groups are distinguished in the order of priority as (1) the Archæan, (2) Purāna, (3) Dravidian, and (4) Aryan groups.

The Pre-Cambrian History of India may be said to contain three elements, viz., the Archæan era, the great Eparchæan break, and the Purāna era.

The *Archæan rocks*, which occupy so great an extent of peninsular India, are sometimes spoken of as the "fundamental complex." This essentially agrees with its development in other countries, and notably in America. "Some of the rocks forming this complex are masses of deep-seated igneous origin: others presumably originated as sand-stones, shales, limestones, lava-flows, and other forms of superficial deposit, which became metamorphosed by close-folding, by

depression to great depths in the crust, and by further injection of igneous material." He divides the Archæan group in India as follows:—

4. Dhārwārian.
   Eruptive unconformity.
3. Granites, anorthosites, charnockite series, norites, etc., of various localities.
2. Schistose and
1. Gneissose rocks.

The Dhārwārs have attracted a special interest on account of the valuable minerals they include: iron-ores in great richness and purity in the Central Provinces and Bellary, copper-ores disseminated at a particular horizon in Singbhūm, and gold in the quartz reefs of Kolār are mentioned.

The Purāna Group.—Upon the weathered surface of the highly folded Dhārwārs and the associated schists and gneisses of the Archæan group enormous thicknesses of sediments were deposited in peninsular India. The break in geological time between these two members of the Pre-Cambrian, or Azoic rocks, appears to the author so enormous as possibly to exceed the entire period of the fossil-bearing rocks, i.e. from the earliest Cambrian to recent times. The Purāna group includes the Cuddapahs of Southern India, amounting to 20,000 feet in thickness with several unconformities. Other examples of this class occur elsewhere in peninsular India, presenting on the whole a lower and an upper series, the latter corresponding generally to the Vindhyans. This is a very interesting formation both topographically, as being conspicuously displayed along the great escarpment of the Vindhyan range, and also lithologically, the rocks being prominently sandstones with subordinate beds of shale and limestone yielding lime and building-stone of considerable economic value. The system is also remarkable for including strata in which diamonds are found, though these, we believe, are part of a bedded sediment, and in no sense indigenous. The author further speculates on the possible existence of representatives of the Purāna group in extra-peninsular areas, and notably in the Himālayas, where unfossiliferous beds, occurring south of the snowy range and crystalline axis, have been referred, without absolute proof, to various members of the regular fossiliferous sequence.

Cambrian and Post-Cambrian History of India.

A. *The Dravidian Era.*

The oldest fossiliferous strata known in India are found in the Salt Range of the Punjab, where beds are exposed with fossils, as previously mentioned, whose nearest relatives occur in the Lower Cambrian. The Salt Range, we may observe, is both an enigma and a godsend to the Indian geologist—an enigma because undoubted Cambrian strata repose on a peculiar marl with beds of rock-salt and gypsum, which may be of Tertiary age; a godsend, because it provides a recognizable base for the palæontological column, but, above all, for its wealth in Permo-Carboniferous fossils, which assist the interpretation of that system in the Himālayas themselves. The

geological history of the Salt Range is a blank between the lowest Cambrian and the Permo-Carboniferous, but there are indications here and there of the older Palæozoics in the central Himálayas, where the Vaikritas and the Haimantas are regarded as Upper Cambrian. The Ordovician is represented in the Kumaun area by a coral limestone; while in Spiti this stage is probably not preserved, the lowest of the Silurian beds being red grits and quartzites, with overlying shales and limestones, which contain fossils like *Halysites catenularia*, indicating an Upper Silurian (Gothlandian) age. The Gothlandian beds are overlain by a grey-to-red limestone, which has not yielded fossils sufficiently well-preserved to determine its exact age, though from its position it is probably Devonian (Muth Beds). A Devonian fauna has been proved to exist in Chitral, the evidence being based chiefly on unusually well-preserved Brachiopods, though with a mixture of Corals, approximating to Upper Silurian forms, and Devonians have also been recognized in Upper Burma.

Above the Muth quartzite there occur grey limestones with numerous Brachiopoda of Upper Carboniferous age, together with associated deposits containing *Phillipsia*, *Fenestella*, etc., probably of Upper Carboniferous or Permo-Carboniferous age. With these beds, the author says, we approach the close of the Dravidian era in Northern India; for at about this horizon, corresponding to the Upper Carboniferous of England, there is an important break in the deposition, and new conditions are introduced by a widespread conglomerate which forms the base of the marine sediments distinguished as the Aryan group.

B. *The Aryan Era.*

This is the most extensive and important of the four primary divisions adopted by Mr. Holland, being equally well represented by marine formations in the extra-peninsular areas as by fresh-water and terrestrial formations in the peninsular area. Its description occupies three-fifths of Mr. Holland's article, and, as it is not possible on the present occasion to go into particulars, we append the table of the Aryan group as set out on p. 55, once more reminding the reader that the Aryan group represents everything from and including the Permo-Carboniferous up to the present day.

In the extra-peninsular area the changes in physical geography which occurred towards the close of the end of the Carboniferous period are marked by a widespread conglomerate in Spiti and Kumaun. This conglomerate forms the basement bed of a great series of strata which were laid down successively, without a sign of interruption or break, throughout a period corresponding to the whole of the Permian and the succeeding Mesozoic era of Europe. This same boulder-bed, of course, looms largely in the Salt Range, where ice conditions have been claimed for its origin as well as for the analogous Talcher boulder-bed of the Gondwāna system. Above this are various beds, some of which contain a prodigious wealth of Permo-Carboniferous marine fossils. We cannot afford to discuss these, but a few words on the Gondwānas of the Peninsula may not be out of place, since, from an economic point of view, this is the most important of all the Indian formations, and possesses a further interest

in the numerous and conflicting interpretations which have been offered as to its true meaning and position in the geological scale; moreover, it is inseparably connected with the bold speculations of Blanford and others as to the existence of a great Mesozoic Indo-African continent.

Table of the Aryan Group.[1]

Marine Formations.	Fresh-water Formations.		Approximate Equivalents.	
Raised beaches; coral-banks.	Recent alluvium; Porbandar-stone; Desert-sand.		Recent.	Post-Tertiary.
Cuddalore sand-stones.	Older alluvium of Narbadá and Godávari.		Pleistocene.	
Makrán Series.	Upper Siwáliks, Irrawaddy Series.		Pliocene.	Tertiary.
Gáj, Yenangyaung, and Prome Series.	Lower Manchhar.		Miocene.	
Nári.	Kasauli.		Oligocene.	
Kirthar, Rániköt, Sabáthu.	... ...		Eocene.	
Ammonites Beaumonti Beds.	Deccan Trap.		Cretaceous.	Mesozoic.
Chikkim Series; Bagh Beds; Ariyalúr, Trichinopoly, and Utatúr Beds.	Lameta Series.			
Spiti shales; massive limestone of Baluchistán; Umia.	Jubbulpore Series.		Jurassic.	
Katrol, Chári, and Patchham Series of Cutch; Hsúnaw Series.	Rájmahál and Mahádeva Series.	Gondwána System.		
Trias of Central Himálayas; Ceratite formations of Salt Range.	Panchet Series.		Triassic.	
Productus-shales and -limestones, Central Himálayas & Salt Range.	Bámuda Series.		Permian.	Palæozoic.
Boulder-bed of Salt Range.	Talcher Boulder-bed.			

The Gondwána System.—Above the youngest member of the Vindhyan system there is a great gap of unknown width in the geological history of peninsular India, and its next chapter commences with a formation deposited on a land-surface, which, it is surmised, had some sort of land connection with Africa and Australia. The basement is known as the Talcher boulder-bed, and a similar boulder-bed is also found in Africa and Australia, all being generally regarded as the result of ice-action, though there does not seem to have been any special glacial fauna associated with such ice-action, as is the case with the great Pleistocene glaciation. Reference has already been made to the analogous boulder-bed in the Salt Range. The author considers that the lowermost beds of the Gondwána system are fixed by indirect evidence as Upper Carboniferous or Permo-Carboniferous in age, whilst the uppermost stages of this system are

[1] Extracted from vol. i of "The India Empire," p. 55.

associated with marine deposits of Oolitic or possibly Neocomian age. The Gondwāna rocks are preserved as small patches mostly let down by faulting into the great crystalline mass of the Peninsula, whilst isolated patches, including coal-beds, have been involved in the folded extra-peninsular area near Darjeeling and in Northern Assam. Next above the Talchers, in peninsular India, comes the Damuda Series, which contain the most valuable Indian coal-seams: the associated rocks are all sandstones and shales, which sometimes attain a thickness of 10,000 feet. The ironstone shale stage is so called on account of the lenses of clay-ironstone which sometimes occur in sufficient abundance to supply a valuable iron-ore. The Pānchet Series completes the Lower Gondwānas, and is devoid of coal-seams, but has yielded reptilian and amphibian bones to a considerable extent.

The three above-named series constitute the lower division of the Gondwāna system, being cut off from the Upper Gondwānas by a marked stratigraphical break, accompanied by a contrast in fossil contents. The plants of the Lower Gondwānas include many equisetaceous forms, while those of the Upper Gondwānas show a prevalence of cycads and conifers; also the species of common genera of ferns, as well as of other orders, are quite distinct in the two divisions. The flora of the Upper Gondwānas is sufficiently abundant, and there are on this horizon great lava-flows, often amygdaloidal like those of the Deccan traps. The predominant flora of the Lower Gondwāna system, in which *Glossopteris* and *Gangamopteris* are prominent genera, has much closer affinities with the Mesozoic plants of Europe than with the plants of the Upper Coal-measures. This fact seemed at first inconsistent with many other evidences pointing to an Upper Palæozoic age for the Lower Gondwānas. "But the explanation offered by the earlier members of the Geological Survey of India, though for many years a stumbling-block to European palæontologists, has received conclusive support in recent times . . . . . With a boulder-bed of Permo-Carboniferous age at the base, and a marine intercalation of Jurassic and Neocomian forms near the summit of the Gondwāna system, we have an inferior and superior limit of the time-scale over which to distribute its various series. A considerable fraction of the lowest beds must represent the Permo-Carboniferous, Permian, and Triassic periods; and yet the plants they contain show, when compared with European fossils, a predominating Rhætic and Jurassic facies."

The author further contends for the former existence of an old Indo-African continent, and claims that this supposed land-barrier is rendered probable by a study of the distribution of Jurassic Cephalopods, whilst the Upper Cretaceous fossils demonstrate the existence of such a land-barrier still more completely. "The great revolutions in physical geography which took place towards the end of the Cretaceous and during early Tertiary times resulted in the break up of the old Gondwāna continent, and were followed by the rise of the Himalayan range."

Whether there ever was such a feature in Permo-Mesozoic times as this supposed continent, which is held to have united in biological affinities regions so remote from each other as India, Africa, and

Australia, we have every reason to be thankful that the stable and conservative tendencies of peninsular India have preserved to us fragmentary portions of an old continental area, if only as a counterpoise to the revolutionary forces which built up the extra-peninsular areas from marine deposits, whose fossils are a testimony to their origin and provide us with an index of geological time. W. H. H.

2. "Indian Empire," Vol. III, pp. 128–167.—Mines and Minerals.

This chapter is also written by Mr. Holland (see preface to vol. iii).

"The feature which stands out most prominently in a survey of the mineral industries of India is the fact that practically nothing has been done to develop those minerals which are essential to modern metallurgical and chemical industries, while most striking progress has been made during recent years in opening out deposits from which products are obtained suitable for export, or for consumption in the country by what may be conveniently called direct processes."

Under the head of "Minerals" are tabulated almost everything which the crust of the earth produces, from mineral oils to quicksilver. If the reader is under the impression that India is a great producer in this respect he will be surprised to learn that the value of imported articles of this class in 1903 (£10,500,000) is rather more than double the value of 'minerals' produced (five millions). And yet it seems to have been worse still in days gone by, since there is an increase in production of 46 per cent. in the five years from 1898 to 1903; hence we may hope that the tables are being turned. The imports of iron, steel, and copper figure very largely, whilst the production of iron-ore is ridiculously small. For many years past gold has headed the list in production, and even in 1903 very nearly half the total of the five millions comes from this source.[1] The most satisfactory feature is the steady increase in the output of coal, which in 1903 was valued at rather more than £1,250,000. Salt, saltpetre, and petroleum are next in importance, though still far behind; whilst mica, manganese ore, and jadestone show respectable figures. One could hardly believe that the country which provided the Mogul emperors with their diamonds imported nearly a million pounds worth of "precious stones and pearls, unset" in 1903, while the Burma rubies scarcely reach the figure of £100,000 by way of balancing the account.

The following is the system of classification of the minerals adopted:—

I. *Carbon and its compounds*, including coal, petroleum, amber, and graphite.

II. *Metalliferous minerals*, including ores of gold, silver, tin, copper, zinc, lead, antimony, iron, manganese, chromium, nickel, cobalt, tungsten, titanium, and aluminium.

III. *Materials for construction*, including building and ornamental stone, etc.

IV. *Minerals used in various industries.*

V. *Gem-stones.*

[1] The total value of gold for 1903 is put down at £2,503,493. In the same year the value of gold produced in West Australia alone is stated to be £8,779,719.

Coal.—During the past twenty years the production of Indian coal has risen from 1,397,818 tons in 1884 to 7,436,386 tons in 1903, the railways being the chief consumers; and this has reduced imported coal to an insignificant figure. Of the total output 95 per cent. was raised from the Gondwāna coalfields of the Peninsula, the remainder being obtained from Tertiary beds in the extra-peninsular area. Bengal is the chief producer, and the most valuable of its coalfields are patches of Gondwāna strata, faulted into the Archæan schists and gneisses, and arranged as a band roughly east to west along the valley of the Dāmuda river. The Rānīganj field, being nearest to Calcutta, still retains its pre-eminence and accounts for $\frac{2}{3}$ of the total mined. Next to Rānīganj in importance is the Jherriā field, about 27 miles by 9½ in extent. Workable coal occurs in the upper stage (Rānīganj), but hitherto operations have been confined to the lower stage (Barākar), in which there are eighteen well-defined and mostly valuable seams, varying from 5 to 30 feet in thickness. As in the Rānīganj field, a large amount of damage has been done to the coal by dykes and sheets of a peculiar igneous rock of the nature of a peridotite. Ten years ago this field was not worked, so that the results may be regarded as of good omen for the Indian coal-industry. The Tertiary coals of the outlying areas are of very little consequence, though much was expected at one time from a working on the Dandot plateau of the Salt Range, where, however, the collieries during the last two years have been worked at a loss.

Gold.—This metal, as regards value, has long headed the list of 'minerals' produced in India, though coal is fast catching it up, and there is very little doubt that 'black diamond' will be at the top of the tree in the course of the next few years. Gold is obtained in small quantities by washing in the river-gravels of various parts of India, but the bulk is mined from a rich reef on the Kolār field in the State of Mysore. The deepest workings, now somewhat more than 3,000 feet below the surface, show little diminution in the value or width of the auriferous quartz-vein. The Dhārwār system of foliated schists, forming the 'country rock' of the auriferous quartz in the Kolār field, is represented by bands of similar rocks folded into the gneisses in various parts of the Peninsula, and many of these show traces of ancient workings, but recent operations other than those in Mysore have only yielded poor results.

Iron-ores.—There seems to be a general consensus of opinion that these are abundant and rich, especially in the Peninsula, but the native iron-smelting industry has been practically stamped out by cheap imported iron and steel within range of the railways. The most abundant iron-ores are the minerals magnetite and hæmatite, which occur in numerous places with quartz, making quartz iron-ore schists which are generally members of the Dhārwār and other Archæan schist series. The clay-ironstones of the Coal-measures, no doubt from their proximity to fuel, are also beginning to attract attention.

Other metals.—There has been a considerable quarrying of *manganese-ore* of late, so that India actually takes second place among the manganese-producing countries of the world. In the Nāgpur area the manganese-ore occurs as lenticular masses and bands in the

quartzites, schists, and gneisses, and appears to have been formed partly by the alteration of rocks composed of manganese-garnet; the ore is typically a mixture of braunite and psilomelane, though it sometimes consists entirely of braunite—a hard, compact, pure ore, ranging well over 51 per cent. of manganese. The metals chromium, cobalt, nickel, tungsten, titanium, and molybdenum do not call for much remark, and the same might apply to copper, tin, lead, etc., which seem to be very little worked at present. *Aluminium* might arrest our attention for a moment, seeing that bauxite is bound to co-exist with the deposits of laterite so abundant throughout the Peninsula and in Burma. The economic development of these deposits must, however, await facilities for the extraction of the purified alumina in India itself.

Turning now to materials for construction, it must be admitted that India is famous for its building-stone. In the far south various igneous rocks are largely used; in the centre, slates and limestones from the Cuddapah Series and basalt from the Deccan trap flows are quarried. In Central India, etc., the great Vindhyan system provides incomparable sandstones and limestones, while in Bengal, etc., the Gondwāna sandstones are used on or near the coalfields. Among the younger rocks the Nummulitic limestones in the north-west and in Assam are largely quarried, while a foraminiferal stone from Kāthiāwār is extensively used in Bombay and Karāchi. Mr. Holland refers to the famous buildings scattered all over India in proof of the excellence of these materials. The Pathāns and Moghuls utilized both the Vindhyan sandstones of Central India and the beds of marble in Rājputāna for building their magnificent mosques, palaces, and tombs in the cities of Northern India. He refers especially to Fatehpur Sikri, where a peculiar red and mottled sandstone was used, and this also, if we mistake not, is equally conspicuous in the forts of Agra and Delhi. Moreover, there is the famous Tāj, "built mainly of white Makrāna marble, with elaborate inlaid work of yellow marble and shelly limestone from Jaisalmer, onyx marble from the Salt Range, black calcareous shales from the Vindhyans of Chitor, malachite from Jaipur, carnelians and bloodstones from the Deccan trap, and red jasper from the Gwalior Series."

Mining for *mica* is also an industry of some importance: it is a muscovite-mica, which occurs in large pegmatite veins traversing mica-schists in various parts of the Peninsula. Nor should we altogether omit to notice the production of *salt*, which ranks next to gold and coal, though a long way behind, in the Table of Values. Nearly half of this is obtained by evaporation from seawater, and is of less interest to the geologist than rock-salt, deposits of which are confined to the Punjab and the North-West Frontier Province—almost the only instance where extra-peninsular strata take precedence of the Peninsula in the matter of production. Some of this occurs in beds of Tertiary age, as at Kohāt near the frontier, but the bulk is raised from the Mayo mines near Kheura in the Salt Range, where the beds, as already noticed, constitute the *apparent* base on which the lowest fossiliferous beds of India rest.[1] The salt-deposits in this area have an aggregate thickness of 550 feet, of which five seams of very pure

material make up 275 feet, while the other half is too earthy and impure to be marketable. There is a difference in the colour of the Kohāt salt and that raised in the Salt Range, and this circumstance, so far as it goes, is rather against the theory of the Tertiary age of the famous salt beds near Kheura.

Gem-stones.—This subject, so interesting to the mineralogist, is apparently of little consequence from an economic point of view, since there is no tabular statement of value beyond that given for the rubies of Burma. The mining for gem-stones is a matter of history, especially in the case of the diamond. The localities for this appear to be confined to the Purāna group of rocks, and are three in number. Probably the most famous is that of the Mahānadī valley, in the eastern part of the Peninsula, where stones of great value have been found formerly in the alluvium, but not in the older rocks. In the Vindhyan conglomerates of Central India the diamond occurs as a sort of pebble near Pannā, and the diamond-mining industry is stated to persist still in this area. No results are given, but we can believe that there may be a sort of underground passage for some of these gems, whose discovery is not recorded on the spot. During the past six years, we are told that the ruby-mining industry in Upper Burma has undergone a favourable change; but, on the whole, it seems to us that even this is disappointing, considering the great expectations at one time formed on the annexation of the country. Other gem-stones, such as sapphire, spinel, beryl, tourmaline, garnet, etc., are found in small quantities. On the other hand, the amygdaloidal flows of the Deccan trap furnish, either directly or indirectly, a considerable number of agates, whilst the jadeite of Upper Burma has really become an important industry. This jadeite is obtained partly in the form of pebbles and partly by quarrying. In the latter case "the jadeite forms a layer in the dark-green serpentine, against which, on a fresh surface, it stands in striking contrast on account of its light colour. The serpentine is apparently intrusive into Miocene sandstones, and the jadeite must have been separated as a primary segregation from the magma." N.B.—The *jadeite* of China is described as a silicate mainly of alumina and soda, of high specific gravity and great hardness, whilst *jade* is a more basic silicate of magnesia and lime. Thus it is singular that the jadeite of Burma should be associated with such a magnesian rock as serpentine, and its composition may differ from that of China.

W. H. H.

II.—Crystalline Schists.

Die Kristallinen Schiefer. Von Dr. U. Grubenmann, Professor der Mineralogie und Petrographie am Eidgenössischen Polytechnikum und an der Universität Zurich. I. Allgemeiner Teil, mit 7 Textfiguren und 2 Tafeln, 9½″ × 6″; pp. vi + 106. Berlin, 1904. M 3·40, bound. II. Specieller Teil, mit 8 Textfiguren und 8 Tafeln, pp. viii + 176. Berlin, 1907, M. 9·60, bound.

THE first of these volumes opens with a historical sketch followed by chapter A (22 pages) on the original material of crystalline schists and its specific characters. The characters of sedimentary and

igneous rocks, the formation of the mineral components, the structures and textures and products of differentiation of the latter group are described. Chapter B (24 pages) treats of Metamorphism, under the headings of solvent, temperature, pressure, and factors peculiar to the substance metamorphosed. Chapter C (41 pages) deals with the product of metamorphism in its different forms of development, viz., mineral composition, structure, texture, separation planes, and jointing. Chapter D (7 pages) is devoted to the geological occurrence of crystalline schists, and is followed by a bibliographical list (4 pages).

In chapter B, under the heading of "Pressure," the fact is dwelt on that under high pressure minerals (and rocks) of high specific gravity, and hence small molecular volume, are formed, and numerical instances (partly from Professor F. Becke's papers) of such volume changes are given. In chapter C, under "Mineral Composition," attention is drawn to the zones of metamorphism in accordance with depth proposed by Mr. C. R. Van Hise[1]; but, whereas Van Hise proposes an upper zone of *catamorphism* and a lower one of *anamorphism*, Dr. Grubenmann proposes three zones—an uppermost zone of moderate temperature (heat being liberated), small hydrostatic pressure, great stress, and predominating mechanical pressure effects; a middle zone of higher temperature (heat being liberated or absorbed), greater hydrostatic pressure, very great stress, predominating chemical pressure effects (decrease of molecular volume); a deepest zone of very high temperature (heat being absorbed), very great hydrostatic pressure, weaker stress, predominating chemical pressure effects (recrystallization without change of form). Dr. Grubenmann maintains that certain minerals and certain rocks are characteristic of each zone, and in his second volume he bases his classification on this view.

Under "Structure," in chapter C, many new terms (most of them suggested by Professor Becke) are introduced, e.g., crystalloblastic, idioblasts, xenoblasts, homœoblastic, heteroblastic, granoblastic, lepidoblastic, nematoblastic, pœciloblastic, etc. Professor E. Weinschenk[2] has found fault with these terms, asserting that they are nothing more than a re-coinage of old terms used to describe contact rocks. Professor Becke, reviewing Professor Weinschenk's book,[3] maintains that his object was to sharply contrast the structures common to crystalline schists with the structures of igneous rocks and give appropriate names.

Dr. Grubenmann's first volume is interesting, and the 12 photographic figures of microscopic structures are instructive, but the rocks represented in the figures, their localities, the minerals shown in the sections, and the amount of magnification are not mentioned.

The second volume begins with 9 pages of historical introduction, followed by 9 pages on the principles of the classification adopted by the author. It is primarily chemical and follows the method of

[1] For full details see his Treatise on Metamorphism (11½"×9"), pp. 1286, with 13 plates and 32 figures. U.S. Geological Survey Monograph, xlvii (1904), reviewed by Mr. A. Harker in *Nature*, lxxiii (1906), p. 450.

[2] "Spezielle Gesteinskunde," Freiburg i/B. 1905, p. 11.

[3] Tschermak's "Mineralogische und Petrographische Mitteilungen," xxv (1906), p. 238.

Dr. A. Osann,[1] the bulk analysis is re-calculated free from water, then the molecular proportions and percentages are calculated, etc. As a result Dr. Grubenmann proposes 12 groups: (1) Alkali felspar gneisses, (2) Silicate of alumina gneisses, (3) Lime soda-felspar gneisses, (4) Eclogites and Amphibolites, (5) Magnesian silicate schists, (6) Jadeite rocks, (7) Chloromelanite rocks, (8) Quartzite rocks, (9) Lime silicate rocks, (10) Marbles, (11) Iron-oxide rocks, (12) Aluminium oxide rocks. Each group is (where possible) divided into three subdivisions in accordance with the three zones of metamorphism proposed in the first volume. The greater part of the volume is occupied by detailed descriptions of the rocks illustrated by 48 photographic figures of microscopical sections, the only fault of which is that the minerals represented in each section are not always indicated.

Although less interesting reading than the first volume the second is likely to be of more practical use. Both volumes have the drawback of being without an index. An author who introduces new terms and leaves one to laboriously search for them handicaps himself. Again, who can tell, *a priori*, that the well-known Saxon granulites are to be looked for in "Die Familie der Biotitarmen Kata-Orthoklasgneisse"? An index would enable one to find them at once.

B. Hobson.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

I.—May 1st, 1907.—Sir Archibald Geikie, D.C.L., Sc.D., Sec.R.S., President, in the Chair.

The following communications were read:—

1. "On the Xerophytic Character of Coal Plants, and a suggested Origin of Coal Beds." By the Rev. Professor George Henslow, M.A., F.L.S., F.G.S.

Of the Palæozoic flora, the *Equisetites*, now represented by the single genus *Equisetum*, are decidedly hygrophytic, if not hydrophytic. The Ferns, which appear to have much resemblance to certain modern types, especially the *Marattiæ*, seem to have lived under more or less similar conditions to the present; that is, varying from the hygrophytic habit of *Hymenophyllum* to the xerophytic *Ceterach*. The *Cycadofilices*, *Cordaites*, etc., are decidedly xerophytic; and the same is the character of the *Lycopodiales*, represented now by *Lycopodium* and *Selaginella*, and of *Psilotum*, *Salisburia*, and others. In fact, the characteristic feature of the great coal forests was xerophytic, and the vegetation appears to be of an upland type. Illustrations are given from recent and Carboniferous plants, to show the characters of leaf, root, and stem which separate these classes of plants. The position of coal-seams is accounted for by the action of

[1] Tschermak's Min. und Pet. Mitteil., xix (1900), p. 351.

earth-movements in late Carboniferous times: these threw the forest-bearing surface into shallow waves and troughs, which became gradually accentuated, the latter being gradually filled with sediment, upon which, during intervals of rest, new forest growth took place.

2. "Petrological Notes on the Igneous Rocks lying to the South-East of Dartmoor." By Harford John Lowe, F.G.S.

The rocks described are contained in the Newton Abbot district, the region east of the Dart and south of the Teign. They are most nearly related, both geologically and petrologically, to those of South-West Devon, or the Plymouth district described by Worth. The numerous intrusions occurring in the Devonian and Culm rocks have been summarized by Dr. Teall as "for the most part referred to the basic kind known as diabases." The Ashprington rocks are finer grained and lighter in colour than those of the other groups: the Newton Devonian specimens range from light greyish-green to nearly black, and in texture from fine to medium; while the Culm specimens are nearly all of coarser texture, occasionally mottled, and on an average of slightly darker shade. The masses of igneous rock in the district do not display such evidence of extreme dynamic stress as is found among the related rocks farther west. The rocks described from the Devonian volcanic group include tuffs, basalts, and diabases (mostly free from olivine, though there are exceptions), pierite, leucophyre, and kersantite. The Culm volcanic rocks show an absence of the finer-grained basaltic class, as well as some distinct difference in mineralogical constitution of the most nearly allied, indicating subjection to different physical conditions. The rocks include tuffs, diabases, proterobases, epidiorites, camptonites, teschenites, hornblende diabases, mica-lamprophyre, and porphyry.

II.—May 15th, 1907.—Sir Archibald Geikie, D.C.L., S.D., Sec.R.S., President, in the Chair.

The following communication was read:—

"On the Origin of certain Cañon-like Valleys associated with Lake-like Areas of Depression." By Frederic William Harmer, F.G.S., F.R.Met.S.

In glaciated regions, as shown by Professor P. F. Kendall, the invasion of a district by an ice-sheet would tend to obstruct the natural drainage, producing lakes, of which the outflow might take place over the advancing ice, between the ice and the hillsides; or it might escape laterally, in a direction at right angles to the longest diameter of the lake and to the course of the pre-existing stream. Overflow channels would assume a gorge-like character, and would present a comparatively recent appearance. During the Glacial Epoch the North Sea ice appears to have invaded the plain of the Witham and the valleys of the Welland, Nene, and Ouse, overriding also the higher land separating them; the Tees ice-stream moved up the Trent basin to the vicinity of Derby and thence, inosculating with the Derwent glacier, up the Soar Valley towards Leicester and

Rugby; the Irish Sea ice passed into the northern part of the basin of the Lower Severn; ice from the Brecknock Beacons passed towards the Bristol Channel and, combined with Irish Sea ice crossing Pembrokeshire from St. David's Head towards Cardiff, may have caused the accumulation of sedentary ice in the Severn Valley. After considering the case of Lake Pickering and the Malton Gorge as a typical example, the author passes on to Lake Shrewsbury and the gorge at Ironbridge. Pre-Glacial drainage of the Upper Severn and Vyrnwy was probably northwards; when a Glacial lake was first formed over the Cheshire plain it may have drained towards the Trent, possibly by Rudyard and Madely; when these gaps were closed, the lowest outlet seems to have been towards the south, and the Severn Gorge at Ironbridge was cut. The cañon of the Camlad at Chirbury, known as Marrington Dingle, appears to have been caused by outflow from a Church Stoke lake which was driven into the Ordovician ground to the north and east. Lake Trowbridge and the gorges of Clifton and Bradford-on-Avon are next dealt with, the latter being attributed to the overflow of a Glacial lake occupying the Trowbridge plain, and the former to the blocking of the Flax-Bourton valley by ice. The gaps in the Jurassic escarpment at Lincoln and Ancaster are explained as overflows from a lake caused by the damming of the Trent outlet towards the Humber. This gave rise at first to the more northern, and later to the southern gorge. Finally, Lake Oxford and the Goring Gap are dealt with in considerable detail. Certain Drift-filled valleys are regarded as excavated by a river flowing from the south-west—the primæval Thames. The distribution of the Chalky Boulder-clay shows that the advance of the Great Eastern Glacier from the north-east must have arrested drainage flowing towards the Wash, and caused a lake which may possibly have first overflowed through the Newport valley into that of the Stort, or by the Hitchin valley into the Lea, or later into the Colne by the Leighton Buzzard valley. When the ice reached Buckingham, such channels were closed and the overflow must have taken place farther to the south-west, over what are now the Tring, Wendlover, and Wycombe Gaps, and eventually by the Goring Gap itself.

Gravels containing Triassic and drifted flint pebbles derived from Glacial deposits may be traced from Goring across the Oxford Plain, at an elevation of between 400 and 500 feet, into the Evenlode Valley, and thence into the basin of the Avon. Their occurrence on the higher slopes of the Goring cañon indicate that the excavation of the latter did not commence until after the arrival of glacially derived detritus in the region in question; the Goring Gap is, therefore, of Glacial age.

The author is unable to reconcile the views here given with those of Professor W. M. Davis on the valley erosion of Central England. Any relation which may have existed between the present drainage system and that of some former period, when a peneplain may have extended over the Jurassic and Cretaceous formations alike, and consequent rivers ran out to sea over it, is remote and impossible to trace. With the exception of the Goring gorge, which may be-

otherwise explained, no connection whatever exists between the drainage systems or the topography of the Cotteswolds and the Chilterns, nor does a vestige remain of the peneplain which, at some unknown height above the present surface, is supposed to have united them. The escarpments form two dip-slopes, to which the streams traversing them are respectively conformable.

The more important rivers of Central England are longitudinal, following the strike of softer rocks along which the predominant erosion has taken place, the transverse drainage being everywhere subsidiary to that of the plains. The excavation of the latter may have taken place at a comparatively early period in a direction not vertical, but inclined more or less with the dip of the softer strata, the formation of the dip-slope and the cutting back of the opposing escarpment being contemporaneous; the erosion of valleys in the dip-slope must have been posterior to this, and could not have preceded it.

III.—June 5th, 1907.—Sir Archibald Geikie, D.C.L., Sc.D., Sec.R.S., President, in the Chair.

At the Ordinary Meeting on May 15th the President announced that the Council had resolved to award the proceeds of the Daniel Pidgeon Fund for 1907 to Miss Ida L. Slater, B.A. (Dublin), Newnham College, Cambridge, who proposes to investigate the Lower Palæozoic rocks in the neighbourhood of Llandeilo.

The following communications were read:—

1. "A Marine Fauna in the Basement Beds of the Bristol Coalfield." By Herbert Bolton, F.R.S.E., F.G.S.

Isolated and rare fossils have been occasionally discovered in the Bristol Coalfield, but the list of genera and species hitherto recorded is a short one. During the progress of an exploration branch at the Ashton Vale Colliery, fossiliferous shales were traversed in the lowest Coal-measures resting upon the Millstone Grit. A section of the Coal-measures in this part of the coalfield is given, the Gays Seam being the lowest workable seam, and the chief fossiliferous shale is localized at a depth of 84 feet below it. The most striking feature of the fossils is their dwarfed condition, especially among the fish-remains. Fossils found in the spoil banks of other pits indicate that other marine horizons occur in the coalfield. The thickness of the Millstone Grit appears to be about 980 feet. The palæontological description embodies a tabular list of fossils from the marine horizon, which shows a close correspondence with the list drawn up from the marine beds associated with the Gin Coal of North Staffordshire: but it does not appear to be desirable to conclude that the horizons are identical, until further evidence of faunal development has been obtained from the Bristol area. The Brachiopod fauna contains forms identical with, or closely approximating to, species occurring in the *Cyathaxonia*- and *Dibunophyllum*-zones.

The palæontological description contains an account of the different

species collected, including notes on *Productus*, *Chonetes*, *Derbya*, and *Orthotheles*, contributed by Dr. A. Vaughan, and new species of *Chonetes*, *Raphistoma*, and *Loxonema*.

2. "Brachiopod Morphology: *Cincta*, *Eudesia*, and the Development of Ribs." By S. S. Buckman, F.G.S.

The test ornament of Brachiopods is found in three main phases—smooth, ribbed, and spinous; and of these three, a costate species is more advanced than a smooth one, and less advanced than a spinose one. There are catagenetic developments, also, in reverse order; but these may, for the present, be neglected. Dall has stated that *Cincta* (*Terebratula numismalis* Group) is a synonym of *Eudesia* (*T. cardium* Group); but, although it would be quite possible for costate forms to be developed from the smooth *Cincta*, yet they would not be costate forms of the *Eudesia* type: in the *Cincta* type the costæ developed would be of the kind which produced opposite carination of both valves, while in *Eudesia* the costæ on the two valves are alternate, the carinæ of one valve being opposed by sulci in the other. This fundamental difference not only prevents the inclusion of *Eudesia* and *Cincta* in one genus, but shows that they belong to entirely different series. The first phase of development dealt with may be called the lenticular stage, which might develop in either of the two directions indicated. The next phase would be the *Cincta* stage, in which the front margin is rounded in youth, truncate in adolescence, incipiently excavate and bilobate in the adult, as the growth-lines of the specimens show. The *Cincta* stage may develop in two directions—out of broad forms the quadrifid stage, out of narrow forms the comite stage. The next development may be called the quadricarinate or trigonellid stage; and the fourth stage, the multicarinate or *pectunculus* stage. In *Eudesia* there is a highly developed multicarinate stage, but the carinæ are alternate, not opposite. In degree of ribbing it is higher than *Cincta*, and in a way even higher than the *pectunculus* stage; but both the ribbing and the loop forbid connection with *Cincta*. The preceding stage is exemplified by *Isudenia pectunculoides*. A prior stage may be seen in *Megerlia Munieri*; and, as an example of the incipient unipliate stage, *Terebratula Whitakeri* may be given. Certain emendations in nomenclature appear to be necessitated as a result of this communication; new names are given, and their application defined. A Table is added to show the successive stages of development along the two lines.

CORRESPONDENCE.

CALCAREOUS NODULES.

Sir,—It is interesting to learn, from Dr. Stopes' article on the relation of the Yarra concretionary nodules and the Lancashire and Yorkshire 'coal-balls,' that her recent researches, in conjunction with Mr. Watson, promise to settle the question of the origin of the latter

examples. In that paper Dr. Stopes states the supposition that the Yarra calcareous nodules are "more nearly approximate" to the clay-ironstone nodules of the Carboniferous. I was not aware, however, that these contained so large a proportion of woody material as we find in the Yarra nodules, the vegetable remains in the 'siderites' being usually in the form of impressions or carbonaceous films. The proportion of argillaceous matter, moreover, in the nodules from the Yarra, is exceedingly small, whilst the amount of calcareous material is comparatively large. Since I omitted to give the percentages in my paper on the subject, they are here appended. From the context of that paper it will be apparent that the qualifying term 'clay' (only once used in connection with these nodules) was a *lapsus calami*.

The analysis of the nodules from the Yarra estuary is as follows:—Carbonaceous matter = 55 per cent.; calcareous = 41 per cent.; arenaceous and argillaceous = 4 per cent. With regard to the occurrence of quartz-grains, zircons, etc., in the Yarra nodules, it will be seen on consideration that these are accidental constituents of the matrix, due to local conditions, and which would in no respect affect the comparison; whilst the solidity and more completely calcified condition of the English 'coal-balls' could be accounted for by difference in age.

I have examined a large number of the English 'coal-balls,' both microscopically and in hand specimens, and had brought with me to Melbourne a number of characteristic examples, which I have used for comparative purposes. I am not in a position, however, to discuss their relation to the beds in which they occur, since I have not examined them *in situ*; and therefore await Dr. Stopes' detailed description with the greater interest. When these results are published we may perhaps also learn whether the stems of *Calamites* and twigs of *Lepidodendron* have been found actually passing from the nodules into the surrounding deposits. In conclusion, be the theory proved either way, personally speaking it will be equally satisfactory to know that the *modus operandi* of their formation has been successfully elucidated.

F. Chapman.

National Museum, Melbourne,
April 16*th*, 1907.

AN UNPUBLISHED LETTER OF SIR JOSEPH PRESTWICH ON SUBMERGENCE OF THE BRITISH ISLANDS IN PLEISTOCENE TIMES.

Sir,—At a time when the views of those who, like myself, hold that the partial submergence of the British Isles is the only way in which the existence of beds with marine shells of living species can be truly accounted for, have been partially discredited by the address of the President of Section C at York last year, it may be well to produce the following letter of Sir Joseph Prestwich, upon which I have accidentally lighted while turning over a book of geological memoranda written some years since. In explanation of this letter I may mention that it was written in answer to one from myself, in which I called

the attention of the writer to the evidence of submersion as afforded by the existence of the high-level shelly gravels of North Wales and Derbyshire, together with the existence of rolled quartz-pebbles scattered over the Cottswold Hills of Gloucestershire, formed of Jurassic limestones, up to 600 feet above sea-level: a fact corroborated by Professor J. Phillips in his "Geology of Oxford." With this preface I proceed to give Prestwich's letter:—

"25*th July*, 1895.

"My dear Hull,—

Thanks for your letter. I quite agree with you as to the important submergence in Glacial times, which has left such clear evidence on the Cottswold Hills and Welsh Mountains. It is surprising to me that the ice-ploughing hypothesis could ever be sustained. Some half-century ago it was my good fortune to come across one of the fossiliferous gravels in the hills (1100 feet) between Chesterfield and Buxton. Why the old simple explanation should ever have been pushed on one side in favour of the more fanciful view I cannot understand, unless it be the innate love of change.

"I am,

Very truly yours,

Joseph Prestwich."

The shelly gravels of Moel Tryfaen, discovered by Trimmer many years since, are well known, having been often described; but those described by Nicholson as occurring at nearly the same level on the Denbighshire Hills (from 1070 to 1170 feet) have not been so generally recognised, and yet are important as indicating the level of submergence over a wide area. The beds occur on the ridge of Millstone Grit of Gloppa, near Oswestry. They are 60 feet in thickness, stratified, and contain numerous marine shells, of which some are living in the Irish Sea and are also found in the Moel Tryfaen beds (Q.J.G.S., vol. xlviii, p. 86).

Before concluding, it may be well in this connection to refer to the important paper by Mr. W. Shone on the "Glacial Deposits of West Cheshire" (Q.J.G.S., vol. xxxiv, p. 383), describing in detail the three divisions of the Drift Series as they are found in Lancashire and Cheshire, and the abundant marine fauna of the Upper Boulder-clay and Middle Sands as they occur near Newton Hollows in West Cheshire, both being underlain by the Lower Boulder-clay. The Upper Boulder-clay is stated to have yielded 57 species and varieties of Mollusca, 2 Polyzoa, 26 Ostracoda, 3 Echini, and the Middle Sands contain 2 species of *Cardium*, also *Tellina baltica* and *Turritella terebra*; from the Lower Boulder Drift shells were absent, but erratic blocks numerous, offering a remarkable contrast to the overlaying marine beds.[1] Those who, with Mr. Lamplugh, refuse to recognise an Interglacial (as well as Upper Glacial) marine stage of the Drift Series, are invited to read Mr. Shone's very instructive paper, which may be considered as descriptive of the Drift deposits as they occur generally throughout the north-west of England.

Edward Hull.

14, Stanley Gardens, Notting Hill, W.
May 20th, 1907.

[1] See also Mr. R. D. Darbishire's paper on the shells from the Macclesfield Drift-beds: Geol. Mag., 1865, pp. 295–299, with a folding-table giving a list of 53 species found there.